=> d his ful

FILE 'REGISTRY' ENTERED AT 10:45:40 ON 22 AUG 2005

```
                E COBALT/CN
L1              1 SEA ABB=ON  PLU=ON  COBALT/CN
                E NICKEL/CN
L2              1 SEA ABB=ON  PLU=ON  NICKEL/CN
```

FILE 'HCAPLUS' ENTERED AT 10:45:58 ON 22 AUG 2005

```
L3         840734 SEA ABB=ON  PLU=ON  L1 OR L2 OR NI/OBI OR NICKEL/OBI OR
                  COBALT/OBI
L4        1201824 SEA ABB=ON  PLU=ON  METAL#/OBI
L5        1822944 SEA ABB=ON  PLU=ON  L3 OR L4
L6            157 SEA ABB=ON  PLU=ON  ALYSSUM/OBI
L7         597371 SEA ABB=ON  PLU=ON  PLANT#/OBI
L8             49 SEA ABB=ON  PLU=ON  PHYTOMINING?/BI
L9             37 SEA ABB=ON  PLU=ON  L8 AND (L6 OR L5)
L10            29 SEA ABB=ON  PLU=ON  L9 AND SOIL#/BI
L11          1643 SEA ABB=ON  PLU=ON  PHYTOREMEDIATION/OBI
L12           541 SEA ABB=ON  PLU=ON  L11 AND L5
L13            16 SEA ABB=ON  PLU=ON  L12 AND L6
L14            13 SEA ABB=ON  PLU=ON  L8 AND L6
L15            23 SEA ABB=ON  PLU=ON  L14 OR L13
L16           201 SEA ABB=ON  PLU=ON  PHYTOEXTRACTION/OBI
L17             7 SEA ABB=ON  PLU=ON  L16 AND L5 AND L6
L18            25 SEA ABB=ON  PLU=ON  L17 OR L15
L19        153751 SEA ABB=ON  PLU=ON  PH/OBI
L20             4 SEA ABB=ON  PLU=ON  L18 AND L19
L21             9 SEA ABB=ON  PLU=ON  PH/BI AND  L18
L22            16 SEA ABB=ON  PLU=ON  L18 NOT L21
L23           251 SEA ABB=ON  PLU=ON  PHYTO/OBI (L) (REMEDIATION/OBI OR MINING/OB
                  I OR EXTRACT?/OBI OR EXTN##/OBI)
L24             7 SEA ABB=ON  PLU=ON  L23 AND L5 AND L6
L25             2 SEA ABB=ON  PLU=ON  L24 AND PH/BI
L26            10 SEA ABB=ON  PLU=ON  L25 OR L21
L27             5 SEA ABB=ON  PLU=ON  L24 NOT L25
L28            17 SEA ABB=ON  PLU=ON  L27 OR L22
```

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=> fil reg
FILE 'REGISTRY' ENTERED AT 10:54:44 ON 22 AUG 2005
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Property values tagged with IC are from the ZIC/VINITI data file
provided by InfoChem.

STRUCTURE FILE UPDATES:   19 AUG 2005  HIGHEST RN 861198-35-8
DICTIONARY FILE UPDATES:  19 AUG 2005  HIGHEST RN 861198-35-8

New CAS Information Use Policies, enter HELP USAGETERMS for details.

TSCA INFORMATION NOW CURRENT THROUGH JANUARY 18, 2005

  Please note that search-term pricing does apply when
  conducting SmartSELECT searches.

**********************************************************************
*                                                                    *
* The CA roles and document type information have been removed from *
* the IDE default display format and the ED field has been added,   *
* effective March 20, 2005.  A new display format, IDERL, is now    *
* available and contains the CA role and document type information. *
*                                                                    *
**********************************************************************

Structure search iteration limits have been increased.  See HELP SLIMITS
for details.

Experimental and calculated property data are now available. For more
information enter HELP PROP at an arrow prompt in the file or refer
to the file summary sheet on the web at:
http://www.cas.org/ONLINE/DBSS/registryss.html

=> d que l1;d l1
L1             1 SEA FILE=REGISTRY ABB=ON  PLU=ON  COBALT/CN



L1   ANSWER 1 OF 1  REGISTRY  COPYRIGHT 2005 ACS on STN
RN   7440-48-4  REGISTRY
ED   Entered STN:  16 Nov 1984
CN   Cobalt (8CI, 9CI)  (CA INDEX NAME)
OTHER NAMES:
CN   ACO 4
CN   C.I. 77320
CN   Co 0138E
CN   Cobalt element
CN   Cobalt-59
CN   N 354Di
CN   R 401
CN   R 401 (metal)
DR   177256-35-8, 184637-91-0, 195161-79-6
MF   Co
CI   COM
LC   STN Files:   ADISNEWS, AGRICOLA, ANABSTR, AQUIRE, BIOBUSINESS, BIOSIS,
```

BIOTECHNO, CA, CABA, CANCERLIT, CAPLUS, CASREACT, CBNB, CEN, CHEMCATS, CHEMLIST, CHEMSAFE, CIN, CSCHEM, CSNB, DDFU, DETHERM*, DIOGENES, DRUGU, EMBASE, ENCOMPLIT, ENCOMPLIT2, ENCOMPPAT, ENCOMPPAT2, HSDB*, IFICDB, IFIPAT, IFIUDB, IPA, MEDLINE, MRCK*, MSDS-OHS, NIOSHTIC, PIRA, PROMT, RTECS*, TOXCENTER, TULSA, ULIDAT, USPAT2, USPATFULL, VETU, VTB
(*File contains numerically searchable property data)
Other Sources: DSL**, EINECS**, TSCA**
(**Enter CHEMLIST File for up-to-date regulatory information)

Co

PROPERTY DATA AVAILABLE IN THE 'PROP' FORMAT

172268 REFERENCES IN FILE CA (1907 TO DATE)
16251 REFERENCES TO NON-SPECIFIC DERIVATIVES IN FILE CA
172399 REFERENCES IN FILE CAPLUS (1907 TO DATE)

=> d que l2;d l2
L2 1 SEA FILE=REGISTRY ABB=ON PLU=ON NICKEL/CN

L2 ANSWER 1 OF 1 REGISTRY COPYRIGHT 2005 ACS on STN
RN 7440-02-0 REGISTRY
ED Entered STN: 16 Nov 1984
CN **Nickel (8CI, 9CI)** (CA INDEX NAME)
OTHER NAMES:
CN 2020SS
CN Alcan 756
CN B 113W
CN C.I. 77775
CN Carbonyl 255
CN Carbonyl Ni 123
CN Carbonyl Ni 283
CN Carbonyl nickel
CN Carbonyl Nickel 123
CN Carbonyl Nickel 283
CN Carbonyl Nickel 287
CN Celmet
CN Celmet 4
CN Cerac N 2003
CN CHT
CN CNS 10 Micron
CN DNI 20
CN E 12
CN E 12 (metal)
CN Exmet 4 Ni X-4/0
CN Fibrex
CN Fibrex (metal fiber)
CN Fibrex P
CN Fibrex P (metal)
CN Fukuda 287
CN Incofoam
CN N 1
CN N 1000 (metal)

CN N 100ES
CN N 154
CN NDHT 90
CN NDT 60
CN NDT 65
CN NDT 90
CN NI 123
CN Ni 210
CN NI 255AC
CN NI 287
CN Ni 4303T
CN Ni-Flake 95
CN Nickel element
CN Nicrobraz LM:BNi 2
CN NiFL
CN NiFW
CN Nikko 255
CN NOT 90
CN Novamet 4SP
CN Novamet 4SP10
CN Novamet 525
CN Novamet CNS 400
ADDITIONAL NAMES NOT AVAILABLE IN THIS FORMAT - Use FCN, FIDE, or ALL for DISPLAY
DR 8049-31-8, 53527-81-4, 134631-46-2, 17375-04-1, 112084-17-0, 39303-46-3, 195161-84-3
MF Ni
CI COM
LC STN Files: AGRICOLA, ANABSTR, AQUIRE, BIOBUSINESS, BIOSIS, BIOTECHNO, CA, CABA, CANCERLIT, CAPLUS, CASREACT, CBNB, CEN, CHEMCATS, CHEMINFORMRX, CHEMLIST, CHEMSAFE, CIN, CSCHEM, CSNB, DDFU, DETHERM*, DRUGU, EMBASE, ENCOMPLIT, ENCOMPLIT2, ENCOMPPAT, ENCOMPPAT2, HSDB*, IFICDB, IFIPAT, IFIUDB, IPA, MEDLINE, MRCK*, MSDS-OHS, NIOSHTIC, PIRA, PROMT, RTECS*, TOXCENTER, ULIDAT, USPAT2, USPATFULL, VTB
(*File contains numerically searchable property data)
Other Sources: DSL**, EINECS**, TSCA**
(**Enter CHEMLIST File for up-to-date regulatory information)

Ni

PROPERTY DATA AVAILABLE IN THE 'PROP' FORMAT

312333 REFERENCES IN FILE CA (1907 TO DATE)
15664 REFERENCES TO NON-SPECIFIC DERIVATIVES IN FILE CA
312578 REFERENCES IN FILE CAPLUS (1907 TO DATE)

=> fil hcaplus
FILE 'HCAPLUS' ENTERED AT 10:55:01 ON 22 AUG 2005
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FILE COVERS 1907 - 22 Aug 2005 VOL 143 ISS 9
FILE LAST UPDATED: 21 Aug 2005 (20050821/ED)

New CAS Information Use Policies, enter HELP USAGETERMS for details.

This file contains CAS Registry Numbers for easy and accurate
substance identification.
'OBI' IS DEFAULT SEARCH FIELD FOR 'HCAPLUS' FILE

=> d que l26
L1 1 SEA FILE=REGISTRY ABB=ON PLU=ON COBALT/CN
L2 1 SEA FILE=REGISTRY ABB=ON PLU=ON NICKEL/CN
L3 840734 SEA FILE=HCAPLUS ABB=ON PLU=ON L1 OR L2 OR NI/OBI OR
NICKEL/OBI OR COBALT/OBI
L4 1201824 SEA FILE=HCAPLUS ABB=ON PLU=ON METAL#/OBI
L5 1822944 SEA FILE=HCAPLUS ABB=ON PLU=ON L3 OR L4
L6 157 SEA FILE=HCAPLUS ABB=ON PLU=ON ALYSSUM/OBI
L8 49 SEA FILE=HCAPLUS ABB=ON PLU=ON PHYTOMINING?/BI
L11 1643 SEA FILE=HCAPLUS ABB=ON PLU=ON PHYTOREMEDIATION/OBI
L12 541 SEA FILE=HCAPLUS ABB=ON PLU=ON L11 AND L5
L13 16 SEA FILE=HCAPLUS ABB=ON PLU=ON L12 AND L6
L14 13 SEA FILE=HCAPLUS ABB=ON PLU=ON L8 AND L6
L15 23 SEA FILE=HCAPLUS ABB=ON PLU=ON L14 OR L13
L16 201 SEA FILE=HCAPLUS ABB=ON PLU=ON PHYTOEXTRACTION/OBI
L17 7 SEA FILE=HCAPLUS ABB=ON PLU=ON L16 AND L5 AND L6
L18 25 SEA FILE=HCAPLUS ABB=ON PLU=ON L17 OR L15
L21 9 SEA FILE=HCAPLUS ABB=ON PLU=ON PH/BI AND L18
L23 251 SEA FILE=HCAPLUS ABB=ON PLU=ON PHYTO/OBI (L) (REMEDIATION/OBI
OR MINING/OBI OR EXTRACT?/OBI OR EXTN##/OBI)
L24 7 SEA FILE=HCAPLUS ABB=ON PLU=ON L23 AND L5 AND L6
L25 2 SEA FILE=HCAPLUS ABB=ON PLU=ON L24 AND PH/BI
L26 10 SEA FILE=HCAPLUS ABB=ON PLU=ON L25 OR L21

=> d que l28
L1 1 SEA FILE=REGISTRY ABB=ON PLU=ON COBALT/CN
L2 1 SEA FILE=REGISTRY ABB=ON PLU=ON NICKEL/CN
L3 840734 SEA FILE=HCAPLUS ABB=ON PLU=ON L1 OR L2 OR NI/OBI OR
NICKEL/OBI OR COBALT/OBI
L4 1201824 SEA FILE=HCAPLUS ABB=ON PLU=ON METAL#/OBI
L5 1822944 SEA FILE=HCAPLUS ABB=ON PLU=ON L3 OR L4
L6 157 SEA FILE=HCAPLUS ABB=ON PLU=ON ALYSSUM/OBI
L8 49 SEA FILE=HCAPLUS ABB=ON PLU=ON PHYTOMINING?/BI
L11 1643 SEA FILE=HCAPLUS ABB=ON PLU=ON PHYTOREMEDIATION/OBI
L12 541 SEA FILE=HCAPLUS ABB=ON PLU=ON L11 AND L5
L13 16 SEA FILE=HCAPLUS ABB=ON PLU=ON L12 AND L6
L14 13 SEA FILE=HCAPLUS ABB=ON PLU=ON L8 AND L6
L15 23 SEA FILE=HCAPLUS ABB=ON PLU=ON L14 OR L13
L16 201 SEA FILE=HCAPLUS ABB=ON PLU=ON PHYTOEXTRACTION/OBI
L17 7 SEA FILE=HCAPLUS ABB=ON PLU=ON L16 AND L5 AND L6
L18 25 SEA FILE=HCAPLUS ABB=ON PLU=ON L17 OR L15
L21 9 SEA FILE=HCAPLUS ABB=ON PLU=ON PH/BI AND L18
L22 16 SEA FILE=HCAPLUS ABB=ON PLU=ON L18 NOT L21

```
L23         251 SEA FILE=HCAPLUS ABB=ON  PLU=ON  PHYTO/OBI (L) (REMEDIATION/OBI
                OR MINING/OBI OR EXTRACT?/OBI OR EXTN##/OBI)
L24           7 SEA FILE=HCAPLUS ABB=ON  PLU=ON  L23 AND L5 AND L6
L25           2 SEA FILE=HCAPLUS ABB=ON  PLU=ON  L24 AND PH/BI
L27           5 SEA FILE=HCAPLUS ABB=ON  PLU=ON  L24 NOT L25
L28          17 SEA FILE=HCAPLUS ABB=ON  PLU=ON  L27 OR L22


=> d .ca l26 1-10;d .ca l28 1-17

L26  ANSWER 1 OF 10  HCAPLUS  COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER:        2004:1069648  HCAPLUS
DOCUMENT NUMBER:         142:302660
TITLE:                   Metal extraction by Alyssum
                         serpyllifolium ssp. lusitanicum on mine-spoil soils
                         from Spain
AUTHOR(S):               Kidd, P. S.; Monterroso, C.
CORPORATE SOURCE:        Departamento de Edafologia y Quimica Agricola,
                         Facultad de Biologia, Universidad de Santiago de
                         Compostela, Santiago de Compostela, 15782, Spain
SOURCE:                  Science of the Total Environment (2005), 336(1-3),
                         1-11
                         CODEN: STENDL; ISSN: 0048-9697
PUBLISHER:               Elsevier Ltd.
DOCUMENT TYPE:           Journal
LANGUAGE:                English
ED   Entered STN:  14 Dec 2004
AB   The efficiency of Alyssum serpyllifolium ssp. lusitanicum (Brassicaceae)
     for use in phytoextn. of polymetallic contaminated soils was evaluated.
     A. serpyllifolium was grown on 2 mine-spoil soils (MS1 and MS2): MS1 is
     contaminated with Cr (283 mg/Kg) and MS2 is moderately contaminated with
     Cr (263 mg/Kg), Cu (264 mg/Kg), Pb (1433 mg/Kg) and Zn (377 mg/Kg).  Soils
     were limed to pH .apprx.6.0 (MS1/Ca and MS2/Ca) or limed and
     amended with NPK fertilizers (MS1/NPK and MS2/NPK).  Biomass was reduced
     on MS2/Ca due to Cu phytotoxicity.  Fertilization increased biomass by
     10-fold on MS1/NPK, but root growth was reduced by 7-fold compared with
     MS1/Ca.  Plants accumulated Mn, Ni and Zn in shoots, and both metal
     content and transportation were generally greater in MS2 than in MS1.  Zn
     bioaccumulation factors (BF, shoot[metal]/soil[metal]) were significantly
     greater in MS2 than in MS1.  However, metal yields were greatest in plants
     grown on MS1/NPK.  Concns. of EDTA-, NH4Cl- and Mehlich 3 (M3)-extractable
     Mn and Zn were greater after plant growth.  Concns. of M3-extractable Cr,
     Ni, Pb and Zn were increased at the rhizosphere.  Sequential extns. showed
     changes in the metal distribution among different soil fractions after
     growth.  This could reflect the buffering capacity of these soils or the
     plants ability to mobilize metals from less plant-available soil pools.
     Results suggest that A. serpyllifolium could be suitable for phytoextn.
     uses in polymetallic-contaminated soils, provided Cu concns. were not
     phytotoxic.  However, further optimization of growth and metal extraction are
     required.
CC   60-4 (Waste Treatment and Disposal)
     Section cross-reference(s): 19
ST   metal extn Alyssum mine spoil soil Spain
IT   Soil reclamation
        (biol., phytoremediation; metal extraction by
        Alyssum serpyllifolium on mine-spoil soils, Spain)
IT   Alyssum serpyllifolium
     Optimization
     Rhizosphere
        (metal extraction by Alyssum serpyllifolium on
```

mine-spoil soils, Spain)
IT Fertilizers
Lime (chemical)
RL: BCP (Biochemical process); BIOL (Biological study); PROC (Process)
(**metal** extraction by **Alyssum** serpyllifolium on
mine-spoil soils, Spain)
IT Plant tissue
(shoot; **metal** extraction by **Alyssum** serpyllifolium on
mine-spoil soils, Spain)
IT 7439-92-1, Lead, processes 7439-96-5, Manganese, processes
7440-02-0, **Nickel**, processes 7440-47-3, Chromium,
processes **7440-48-4**, **Cobalt**, processes 7440-50-8,
Copper, processes 7440-66-6, Zinc, processes
RL: POL (Pollutant); REM (Removal or disposal); OCCU (Occurrence); PROC
(Process)
(**metal** extraction by **Alyssum** serpyllifolium on
mine-spoil soils, Spain)
REFERENCE COUNT: 31 THERE ARE 31 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L26 ANSWER 2 OF 10 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2003:442280 HCAPLUS
DOCUMENT NUMBER: 139:322984
TITLE: **Phytoextraction** of **Ni** and Zn from moderately contaminate soils
AUTHOR(S): Scullion, J.
CORPORATE SOURCE: Soil Science Unit, Institute of Biological Sciences, University of Wales, Penglais Aberystwyth, UK
SOURCE: Land Reclamation: Extending the Boundaries, Proceedings of the International Conference of the International Affiliation of Land Reclamationists, 7th, Runcorn, United Kingdom, May 13-16, 2003 (2003), 179-184. Editor(s): Moore, Heather M.; Fox, Howard R.; Elliott, Scott. A. A. Balkema: Rotterdam, Neth. CODEN: 69DZXE; ISBN: 90-5809-562-2
DOCUMENT TYPE: Conference
LANGUAGE: English
ED Entered STN: 10 Jun 2003
AB Phys. degraded soils from 2 disused landfarms had elevated Ni, Zn and oil hydrocarbon concns. Pot trials evaluated amendments (three rates of EDTA or sulfur) for increasing metal uptake by plants (Brassica juncea, Lolium perenne and Alyssum argenteum). Plant growth, foliar metal concns., extractable soil and "leachate" metal concns. were measured. Plants did not grow well (<30% of yield in compost) in landfarm soil. Without amendments, foliar Ni and Zn concns., metal availability and contamination of drainage water were low. EDTA and sulfur increased metal availability and uptake by plants. However, highest input rates reduced yields and metal offtake. Highest metal offtakes were equivalent to redns. less than 3 mg kg-1 soil Ni and Zn. Alyssum argenteum contained Ni concns. 5 times those of L. perenne, but growth was poor and concns. low in unamended soils. EDTA and the highest rate of sulfur caused persistent increases in Ni and Zn leaching.
CC 19-9 (Fertilizers, Soils, and Plant Nutrition)
ST **nickel** zinc soil **phytoremediation** Lolium
Alyssum BRASSICA
IT **Alyssum** argenteum
Brassica juncea
Lolium perenne
Soil amendments
Soil pollution

pH
(**phytoextn.** of **Ni** and Zn from moderately contaminate soils)
IT Remediation
(**phytoremediation**; **phytoextn.** of **Ni** and Zn from moderately contaminate soils)
IT Biological transport
(uptake; **phytoextn.** of **Ni** and Zn from moderately contaminate soils)
IT **7440-02-0**, **Nickel**, occurrence 7440-66-6, Zinc, occurrence
RL: POL (Pollutant); REM (Removal or disposal); OCCU (Occurrence); PROC (Process)
(**phytoextn.** of **Ni** and Zn from moderately contaminate soils)
REFERENCE COUNT: 13 THERE ARE 13 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L26 ANSWER 3 OF 10 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2003:170616 HCAPLUS
DOCUMENT NUMBER: 138:337283
TITLE: **Phytoextraction** of **Nickel** and **Cobalt** by Hyperaccumulator **Alyssum** Species Grown on **Nickel**-Contaminated Soils
AUTHOR(S): Li, Yin-M.; Chaney, Rufus L.; Brewer, Eric P.; Angle, J. Scott; Nelkin, Jay
CORPORATE SOURCE: Viridian Environmental LLC, Houston, TX, 77265, USA
SOURCE: Environmental Science and Technology (2003), 37(7), 1463-1468
CODEN: ESTHAG; ISSN: 0013-936X
PUBLISHER: American Chemical Society
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 07 Mar 2003
AB Several Alyssum species native to Mediterranean serpentine soils hyperaccumulate nickel. These species can potentially be used to remediate Ni-contaminated soils. However, the ability of these species to phytoext. Ni from nonserpentine Ni-contaminated soils is unknown. Two Ni hyperaccumulator species, Alyssum murale and Alyssum corsicum, were grown for 120 days on two nonserpentine Ni-contaminated soils in a greenhouse experiment Soils were amended to provide a range of values for three soil factors: soil **pH**, available phosphorus, and exchangeable Ca/Mg ratio. Both species hyperaccumulated Ni, but not Co, from both soils. Ni uptake was reduced at lower soil **pH** and increased at higher soil **pH**. Neither P fertilization nor adjustment of the exchangeable Ca/Mg ratio significantly affected phytoextn. of Ni or Co. There was no difference between the two species in the amount of Ni phytoextd., but A. corsicum phytoextd. more Co than A. murale. Higher amts. of both metals were phytoextd. from the loam than from the organic soil. Further research is needed to better understand the unusual effect of soil **pH** adjustment on Ni uptake by these hyperaccumulator species.
CC 19-9 (Fertilizers, Soils, and Plant Nutrition)
Section cross-reference(s): 60
ST **phytoextn nickel cobalt Alyssum** species contaminated soil; hyperaccumulator plant **nickel** uptake soil remediation
IT Soil reclamation
(biol.; **phytoextn.** of **nickel** and **cobalt** by hyperaccumulator **Alyssum** species grown on **nickel** -contaminated soils)

IT Soils
(contaminated, loamy and organic; **phytoextn.** of **nickel** and **cobalt** by hyperaccumulator **Alyssum** species grown on **nickel**-contaminated soils)
IT Species differences
(in **cobalt** uptake by hyperaccumulator **Alyssum** species on **nickel**-contaminated soils)
IT Root absorption
Soil acidity
(**nickel** and **cobalt** uptake by hyperaccumulator **Alyssum** species on contaminated soils response to phosphorus fertilizer, exchangeable calcium/magnesium ratio, and soil **pH**)
IT **Alyssum** corsicum
Alyssum murale
Soil pollution
(**phytoextn.** of **nickel** and **cobalt** by hyperaccumulator **Alyssum** species grown on **nickel**-contaminated soils)
IT Fertilizer experiment
(with phosphorus with hyperaccumulator **Alyssum** species on **nickel**-contaminated soils)
IT 7723-14-0, Phosphorus, biological studies
RL: AGR (Agricultural use); BSU (Biological study, unclassified); BIOL (Biological study); USES (Uses)
(**nickel** and **cobalt** uptake by hyperaccumulator **Alyssum** species on contaminated soils response to phosphorus fertilizer, exchangeable calcium/magnesium ratio, and soil **pH**)
IT 7439-95-4, Magnesium, biological studies 7440-70-2, Calcium, biological studies
RL: BSU (Biological study, unclassified); BIOL (Biological study)
(**nickel** and **cobalt** uptake by hyperaccumulator **Alyssum** species on contaminated soils response to phosphorus fertilizer, exchangeable calcium/magnesium ratio, and soil **pH**)
IT **7440-02-0**, **Nickel**, occurrence **7440-48-4**, **Cobalt**, occurrence
RL: BCP (Biochemical process); POL (Pollutant); REM (Removal or disposal); BIOL (Biological study); OCCU (Occurrence); PROC (Process)
(**phytoextn.** of **nickel** and **cobalt** by hyperaccumulator **Alyssum** species grown on **nickel**-contaminated soils)
REFERENCE COUNT: 41 THERE ARE 41 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L26 ANSWER 4 OF 10 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2002:889601 HCAPLUS
DOCUMENT NUMBER: 137:355813
TITLE: Recovery of metal values from soil by hyperaccumulation in plants with **pH** control
INVENTOR(S): Chaney, Rufus L.; Angle, J. Scott; Li, Yin-ming; Baker, Alan J. M.
PATENT ASSIGNEE(S): USA
SOURCE: U.S. Pat. Appl. Publ., 13 pp., Cont.-in-part of U.S. Ser. No. 386,373, abandoned.
CODEN: USXXCO
DOCUMENT TYPE: Patent
LANGUAGE: English
FAMILY ACC. NUM. COUNT: 3

PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
US 2002174451	A1	20021121	US 1999-437607	19991110
US 5711784	A	19980127	US 1995-470440	19950606
CA 2296116	AA	19981230	CA 1997-2296116	19970620
AU 9734787	A1	19990104	AU 1997-34787	19970620
AU 744810	B2	20020307		
US 5944872	A	19990831	US 1997-879813	19970620
EP 993510	A1	20000419	EP 1997-931061	19970620
EP 993510	B1	20030319		
R: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT, IE, FI				
BR 9714799	A	20001010	BR 1997-14799	19970620
JP 2002511904	T2	20020416	JP 1999-504334	19970620
TR 9903145	T2	20021223	TR 1999-9903145	19970620
AT 234940	E	20030415	AT 1997-931061	19970620
PT 993510	T	20030731	PT 1997-931061	19970620
ES 2195154	T3	20031201	ES 1997-931061	19970620
BG 64218	B1	20040531	BG 1999-103975	19991209

PRIORITY APPLN. INFO.:		
US 1995-470440	A1	19950606
US 1997-879813	A2	19970620
US 1999-386373	B2	19990831
EP 1997-931061	A	19970620
WO 1997-US9806	A	19970620

ED Entered STN: 22 Nov 2002

AB The invention relates to recovering metals, such as nickel and cobalt, by **phytomining** or phytoextg. soils rich in metals wherein the desired metal is selectively accumulated in hyperaccumulator plants by adjusting the soil **pH.** The metals are ultimately recovered from above-ground plant tissues at economically acceptable levels without further contaminating the metal-containing sites. The invention also relates to metal-hyperaccumulating plants.

IC ICM C12N015-87

INCL 800278000

CC 54-2 (Extractive Metallurgy)
Section cross-reference(s): 11, 19

ST metal recovery soil cultivation **phytomining**; soil **pH** **Alyssum** plant hyperaccumulation metal; nickel **phytomining** serpentine soil **pH** control

IT Limestone, uses
RL: MOA (Modifier or additive use); USES (Uses)
(dolomitic, soil **pH** control with; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT Weight
(dry, of plant nickel content; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT Lime (chemical)
RL: MOA (Modifier or additive use); USES (Uses)
(hydrated, soil **pH** control with; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT Decontamination
(of metal-containing soils; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT Combustion
Drying
(of plant for recovery of nickel; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT Ablation

Oxidation
(of plant organic material for recovery of nickel; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT Materials
(organic, of plant oxidized for nickel recovery; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT Metals, preparation
RL: PUR (Purification or recovery); PREP (Preparation)
(**phytomining** of, from soils; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT **Alyssum**
Alyssum argenteum
Alyssum bertolonii
Alyssum caricum
Alyssum corsicum
Alyssum fallacinum
Alyssum heldreichii
Alyssum lesbiacum
Alyssum murale
Alyssum pintodasilvae
Alyssum pterocarpum
Alyssum serpyllifolium
Alyssum serpyllifolium malacitanum
Alyssum tenium
(**phytomining** with, from soils; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT Embryophyta
Plant tissue
Pollen
Seed
Soils
pH
(recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT Serpentine-group minerals
RL: MOA (Modifier or additive use); USES (Uses)
(soils with, **phytomining** of; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT 7439-88-5P, Iridium, preparation 7440-02-0P, Nickel, preparation
7440-04-2P, Osmium, preparation 7440-05-3P, Palladium, preparation
7440-06-4P, Platinum, preparation 7440-15-5P, Rhenium, preparation
7440-16-6P, Rhodium, preparation 7440-18-8P, Ruthenium, preparation
7440-48-4P, Cobalt, preparation
RL: PUR (Purification or recovery); PREP (Preparation)
(recovery of, from soil; metal value recovery from soil by hyperaccumulation in plants with **pH** control)

IT 7440-70-2, Calcium, biological studies
RL: BSU (Biological study, unclassified); BIOL (Biological study)
(soil containing; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT 16389-88-1, Dolomite, uses
RL: MOA (Modifier or additive use); USES (Uses)
(soil **pH** control with; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

L26 ANSWER 5 OF 10 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2001:82685 HCAPLUS
DOCUMENT NUMBER: 134:310567
TITLE: **Phytoextraction** of soil **cobalt**

using hyperaccumulator plants
AUTHOR(S): Malik, Minnie; Chaney, Rufus L.; Brewer, Eric P.; Li, Yin-Ming; Angle, J. Scott
CORPORATE SOURCE: Department of Natural Resource Sciences and Landscape Architecture, University of Maryland, College Park, MD, 20742, USA
SOURCE: International Journal of Phytoremediation (2000), 2(4), 319-329
CODEN: IJPHFG; ISSN: 1522-6514
PUBLISHER: CRC Press LLC
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 05 Feb 2001
AB A greenhouse study was conducted on phytoextn. of cobalt by nickel hyperaccumulators Alyssum murale and Alyssum corsicum and by two varieties of cobalt accumulator Nyssa sylvatica compared with the nonmetal accumulator crop plant Brassica juncea. The plants were grown on Sassafras sandy loam soil (<2 mg Co and 5 mg Ni/kg dry soil), amended with 1 mmol Co/kg dry soil (58.9 mg/kg), and two Ni smelter-contaminated soils, Quarry muck with 24 mg Co and 1720 mg Ni/kg dry soil and Welland loam with 37 mg Co and 2570 mg Ni/kg dry soil. All soils were adjusted to **pH** 6.5 to prevent Ni phytotoxicity. Of the five plant entries tested in the study, the two Alyssum species demonstrated the most promising Co phytoextn. results. In Co-amended Sassafras soil, the maximum concentration accumulated by Alyssum murale was 1320 mg Co/kg dry weight, which was almost 60 times higher than accumulation by crop plant Brassica juncea. At a single harvest after 60 days of growth, A. murale was able to extract more than 3% of Co from Co-amended soil. As expected, both Alyssum species accumulated up to 1% Ni on dry weight basis when grown on Ni-contaminated soils. Nyssa sylvatica showed considerable Co accumulation; foliar Co concentration in the second harvest was as high as 800 mg/kg dry weight The first few leaves that emerged were chlorotic, both in the Co-amended soil and Ni-contaminated soils, but with growth the signs of toxicity disappeared. In the Co amended soil, Co concentration in Nyssa sylvatica leaves was 30% of that found in shoots of Alyssum species, but an order of magnitude higher than that of Brassica juncea. The leaves accumulated a higher concentration compared with the stems. Both Alyssum species and Nyssa sylvatica offer promise for phytoextn. of Co and 60Co from contaminated or mineralized soils.
CC 19-9 (Fertilizers, Soils, and Plant Nutrition)
ST soil **phytoremediation cobalt Alyssum** Nyssa
IT Soil reclamation
(biol.; **phytoextn.** of soil **cobalt** using hyperaccumulator plants in)
IT **Alyssum** corsicum
Alyssum murale
Brassica juncea
Nyssa sylvatica
(**phytoextn.** of soil **cobalt** using hyperaccumulator plants)
IT Soil pollution
(**phytoextn.** of soil **cobalt** using hyperaccumulator plants in)
IT **7440-48-4**, **Cobalt**, occurrence
RL: POL (Pollutant); OCCU (Occurrence)
(**phytoextn.** of soil **cobalt** using hyperaccumulator plants)
REFERENCE COUNT: 40 THERE ARE 40 CITED REFERENCES AVAILABLE FOR THIS

L26 ANSWER 6 OF 10 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2000:335610 HCAPLUS
DOCUMENT NUMBER: 132:350586
TITLE: Recovery of metal values from soil by hyperaccumulation in plants with **pH** control
INVENTOR(S): Chaney, Rufus L.; Angle, Jay Scott; Li, Yin-Ming; Baker, Alan J. M.
PATENT ASSIGNEE(S): USA
SOURCE: PCT Int. Appl., 44 pp.
CODEN: PIXXD2
DOCUMENT TYPE: Patent
LANGUAGE: English
FAMILY ACC. NUM. COUNT: 3
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
WO 2000028093	A1	20000518	WO 1999-US26443	19991110
W: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, AM, AZ, BY, KG, KZ, MD, RU, TJ, TM				
RW: GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW, AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG				
CA 2296116	AA	19981230	CA 1997-2296116	19970620
AU 9734787	A1	19990104	AU 1997-34787	19970620
AU 744810	B2	20020307		
EP 993510	A1	20000419	EP 1997-931061	19970620
EP 993510	B1	20030319		
R: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT, IE, FI				
BR 9714799	A	20001010	BR 1997-14799	19970620
JP 2002511904	T2	20020416	JP 1999-504334	19970620
TR 9903145	T2	20021223	TR 1999-9903145	19970620
AT 234940	E	20030415	AT 1997-931061	19970620
PT 993510	T	20030731	PT 1997-931061	19970620
ES 2195154	T3	20031201	ES 1997-931061	19970620
CA 2348483	AA	20000518	CA 1999-2348483	19991110
CA 2348483	C	20041012		
BR 9915206	A	20010731	BR 1999-15206	19991110
EP 1133576	A1	20010919	EP 1999-956971	19991110
R: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT, IE, SI, LT, LV, FI, RO				
TR 200101331	T2	20010921	TR 2001-200101331	19991110
TR 200200389	T2	20020621	TR 2002-200200389	19991110
TR 200200268	T2	20020821	TR 2002-200200268	19991110
JP 2002529234	T2	20020910	JP 2000-581259	19991110
AU 775573	B2	20040805	AU 2000-13461	19991110
AU 2000013461	A5	20000529		
BG 64218	B1	20040531	BG 1999-103975	19991209
ZA 2001003791	A	20031107	ZA 2001-3791	20010510

PRIORITY APPLN. INFO.:		
US 1998-107797P	P	19981110
US 1998-109443P	P	19981123
US 1999-386373	A	19990831
AU 1997-34787	A3	19970620

EP 1997-931061	A	19970620
WO 1997-US9806	A	19970620
WO 1999-US26443	W	19991110

ED Entered STN: 19 May 2000

AB The metal values in soil (especially Ni and Co) are selectively recovered by increasing the **pH**, and cultivating the metal-hyperaccumulating plants for **phytomining.** The soil **pH** is typically increased by the addition of limestone, lime, and/or dolomite, followed by cultivation of Alyssum plants for the metal recovery into the tissues at ≥0.1%. The process is suitable for the Ni recovery at 2.5-4.0% of the dry plant tissues, and preferably decreases metal contamination in the soil. The process can be repeated at a different **pH** of the soil for addnl. recovery of Co, Pd, Rh, Ru, Pt, Ir, Os, and/or Re as the metal values. The serpentine-based soil containing 100-5000 ppm Ni was cultivated with Alyssum murale 103 plants in 4-L vases with the field **pH** of 6-6.6 after adding powdered CaCO3, and showed the typical Ni recovery of .apprx.10,000 mg/kg of dry tissues, vs. .apprx.5000 mg/kg when the soil was initially acidified with HNO3 for decreased field **pH.** The typical metal recovery from the soil with the field **pH** of 6.34 was Ni 11,000, Co 16.2, Mn 39.1, Zn 51.8, Fe 186, and Cu 2.2 mg/kg of dry tissues.

IC ICM C21B009-00
ICS C22B009-00; A01H003-02; A01H005-00; A01G001-00

CC 54-2 (Extractive Metallurgy)
Section cross-reference(s): 19

ST metal recovery soil cultivation **phytomining**; soil **pH** **Alyssum** plant hyperaccumulation metal; nickel **phytomining** serpentine soil **pH** control

IT Metals, processes
RL: PEP (Physical, engineering or chemical process); PROC (Process)
(**phytomining** of, from soils; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT Soils
(**phytomining** of; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT **Alyssum**
Alyssum murale
(**phytomining** with, from soils; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT Lime (chemical)
Limestone, uses
RL: MOA (Modifier or additive use); USES (Uses)
(soil **pH** control with; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT Serpentine-group minerals
RL: MOA (Modifier or additive use); USES (Uses)
(soils with, **phytomining** of; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

IT 7439-88-5, Iridium, processes 7440-02-0, Nickel, processes 7440-04-2, Osmium, processes 7440-05-3, Palladium, processes 7440-06-4, Platinum, processes 7440-15-5, Rhenium, processes 7440-16-6, Rhodium, processes 7440-18-8, Ruthenium, processes 7440-48-4, Cobalt, processes
RL: PEP (Physical, engineering or chemical process); PROC (Process)
(recovery of, from soil; metal value recovery from soil by hyperaccumulation in plants with **pH** control)

IT 16389-88-1, Dolomite, uses
RL: MOA (Modifier or additive use); USES (Uses)
(soil **pH** control with; recovery of metal values from soil by hyperaccumulation in plants with **pH** control)

REFERENCE COUNT: 3 THERE ARE 3 CITED REFERENCES AVAILABLE FOR THIS

L26 ANSWER 7 OF 10 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 1998:163721 HCAPLUS
DOCUMENT NUMBER: 128:195017
TITLE: Recovery of nickel, cobalt, and other metal values from soil by **phytomining** with ion control and acidic conditions
INVENTOR(S): Chaney, Rufus L.; Angle, Jay Scott; Li, Yin-Ming
PATENT ASSIGNEE(S): Chaney, Rufus L., USA; Angle, Jay Scott; Li, Yin-Ming
SOURCE: PCT Int. Appl., 50 pp.
CODEN: PIXXD2
DOCUMENT TYPE: Patent
LANGUAGE: English
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.		DATE
WO 9808991	A1	19980305	WO 1997-US15109		19970829
W: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, AM, AZ, BY, KG, KZ, MD, RU, TJ, TM					
RW: GH, KE, LS, MW, SD, SZ, UG, ZW, AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG					
CA 2272849	AA	19980305	CA 1997-2272849		19970829
AU 9742380	A1	19980319	AU 1997-42380		19970829
US 6786948	B1	20040907	US 1999-147721		19990224
PRIORITY APPLN. INFO.:			US 1996-24928P	P	19960830
			US 1996-30462P	P	19961106
			WO 1997-US15109	W	19970829

ED Entered STN: 19 Mar 1998
AB The Ni, Co, and other metals in laterite and similar soils are recovered by: (a) growing of plants of the Ni-hyperaccumulation type in the soil at **pH** <7 and Ca-ion concentration of 0.128-5 mM; (b) harvesting the plants at ≥2.5% of Ni in the plant tissue; and (c) drying the harvested plants and combusting them to ash for conventional metal recovery and separation The process is suitable for Ni recovery by the plants of the Alyssum genus grown in serpentine-type (or industrially contaminated) soils, especially with the addition of Ni-chelation agents in the presence of Fe, Mg, and Ca ions, as well as the addition of NH4-type fertilizer to the soil. The Ni uptake is associated with the recovery of Co, and is further increased when the ratio of exchangeable Ca/Mg ions is 0.16-0.40. The hyperaccumulating plants are typically Alyssum murale and A. pintodasilvae, and show the optimized Ni content of 10-20 g/kg of shoot growth.
IC ICM C22B023-00
CC 54-2 (Extractive Metallurgy)
Section cross-reference(s): 19
ST **phytomining** metal **Alyssum** plant growth soil; nickel recovery **Alyssum** plant growth soil
IT Fertilizers
RL: BMF (Bioindustrial manufacture); BIOL (Biological study); PREP (Preparation)
(ammonium, in **phytomining**; plant growth method for recovery of nickel and related metals from soils with optimized ion control in

acidic range)
IT Soils
(metals from, by **phytomining**; plant growth method for recovery of nickel and related metals from soils with optimized ion control in acidic range)
IT Metals, preparation
RL: BMF (Bioindustrial manufacture); BIOL (Biological study); PREP (Preparation)
(**phytomining** of, from soils; plant growth method for recovery of nickel and related metals from soils with optimized ion control and acidic conditions)
IT **Alyssum** lesbiacum
Alyssum murale
Alyssum pintodasilvae
Alyssum tenium
RL: BMF (Bioindustrial manufacture); BIOL (Biological study); PREP (Preparation)
(**phytomining** with; plant growth method for recovery of nickel and related metals from soils with optimized ion control in acidic range)
IT 7439-96-5, Manganese, uses 7440-50-8, Copper, uses 7440-66-6, Zinc, uses
RL: MOA (Modifier or additive use); USES (Uses)
(soils containing, **phytomining** of; plant growth method for recovery of nickel and related metals from soils with optimized ion control and acidic conditions)
REFERENCE COUNT: 1 THERE ARE 1 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L26 ANSWER 8 OF 10 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 1998:75947 HCAPLUS
DOCUMENT NUMBER: 128:130530
TITLE: **Phyto-mining** of **nickel**, **cobalt** and other **metals** from soils of lean-ore sites by cultivation of plants
INVENTOR(S): Chaney, Rufus L.; Angle, Jay Scott; Baker, Alan J. M.; Li, Yin-Ming
PATENT ASSIGNEE(S): University of Maryland At College Park, USA
SOURCE: U.S., 4 pp.
CODEN: USXXAM
DOCUMENT TYPE: Patent
LANGUAGE: English
FAMILY ACC. NUM. COUNT: 3
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
US 5711784	A	19980127	US 1995-470440	19950606
CA 2296116	AA	19981230	CA 1997-2296116	19970620
WO 9859080	A1	19981230	WO 1997-US9806	19970620
W: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, AM, AZ, BY, KG, KZ, MD, RU, TJ, TM				
RW: GH, KE, LS, MW, SD, SZ, UG, ZW, AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG				
AU 9734787	A1	19990104	AU 1997-34787	19970620
AU 744810	B2	20020307		

US 5944872	A	19990831	US 1997-879813	19970620
EP 993510	A1	20000419	EP 1997-931061	19970620
EP 993510	B1	20030319		
R: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT, IE, FI				
BR 9714799	A	20001010	BR 1997-14799	19970620
JP 2002511904	T2	20020416	JP 1999-504334	19970620
TR 9903145	T2	20021223	TR 1999-9903145	19970620
AT 234940	E	20030415	AT 1997-931061	19970620
PT 993510	T	20030731	PT 1997-931061	19970620
ES 2195154	T3	20031201	ES 1997-931061	19970620
US 2002174451	A1	20021121	US 1999-437607	19991110
BG 64218	B1	20040531	BG 1999-103975	19991209
PRIORITY APPLN. INFO.:			US 1995-470440	A 19950606
			EP 1997-931061	A 19970620
			US 1997-879813	A2 19970620
			WO 1997-US9806	A 19970620
			US 1999-386373	B2 19990831

ED Entered STN: 09 Feb 1998

AB The Ni and similar metal values in lateritic soil are recovered by cultivation of Alyssum plants of the Brassicaceae family grown under the conditions selected for high accumulation of metals, followed by harvesting and conventional metal recovery from the biomass product. The Alyssum plants are resistant to poisoning by Ni and other heavy metals. The Ni content ≥2.5% in the plant biomass is obtained by conditioning the soil for **pH** of 4.5-6.2, holding the Ca-exchange content at <20% of the Mg-exchange content of the soil, and adding NH4-containing fertilizer and a chelating agent to the soil to promote high metal transfer to the plants. The process is suitable for Ni recovery from the soils of lateritic, ultramafic, or serpentine type, and promotes the metal concentration in biomass at nominally 10-20 times that in the soils.

IC ICM C22B003-18
INCL 075712000
CC 54-2 (Extractive Metallurgy)
Section cross-reference(s): 19
ST **nickel** soil recovery **Alyssum** plant cultivation; lateritic soil **metal** recovery plant growth
IT Soils
(Latosols, **metals** from; **phyto-mining** of **nickel** and similar **metals** from lean-ore soils by plant cultivation)
IT Fertilizers
RL: PEP (Physical, engineering or chemical process); PROC (Process)
(ammonium-containing, in **metal** recovery; **phyto-mining** of **nickel** and similar **metals** from lean-ore soils by plant cultivation)
IT **Alyssum**
(cultivation of, for **metal** recovery; **phyto-mining** of **nickel** and similar **metals** from lean-ore soils by plant cultivation)
IT Chelating agents
(in **metal** recovery; **phyto-mining** of **nickel** and similar **metals** from lean-ore soils by plant cultivation)
IT **Mining**
(**phyto-**, **metal** recovery by; **phyto-mining** of **nickel** and similar **metals** from lean-ore soils by plant cultivation)
IT **7440-02-0**, **Nickel**, processes **7440-48-4**, **Cobalt**, processes

RL: PEP (Physical, engineering or chemical process); PROC (Process)
(recovery of, from soils; **phyto-mining** of **nickel** and similar **metals** from lean-ore soils by plant cultivation)

REFERENCE COUNT: 3 THERE ARE 3 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L26 ANSWER 9 OF 10 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 1997:640604 HCAPLUS
DOCUMENT NUMBER: 127:277699
TITLE: Hyperaccumulation of **metals** in plant shoots, useful for soil **phytoremediation**
INVENTOR(S): Ensley, Burt D.; Blaylock, Michael J.; Dushenkov, Slavik; Kumar, Nanda P. B. A.; Kapulnik, Yoram; Huang, Jianwei
PATENT ASSIGNEE(S): Phytotech, Inc., USA
SOURCE: PCT Int. Appl., 67 pp.
CODEN: PIXXD2
DOCUMENT TYPE: Patent
LANGUAGE: English
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
WO 9734714	A1	19970925	WO 1997-US4956	19970319
W: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, AM, AZ, BY, KG, KZ, MD, RU, TJ, TM				
RW: GH, KE, LS, MW, SD, SZ, UG, AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG				
US 5917117	A	19990629	US 1996-621138	19960321
CA 2249353	AA	19970925	CA 1997-2249353	19970319
AU 9724242	A1	19971010	AU 1997-24242	19970319
AU 725833	B2	20001019		
EP 888197	A1	19990107	EP 1997-919929	19970319
R: AT, BE, CH, DE, DK, ES, FR, GB, LI, NL, SE, PT, FI				

PRIORITY APPLN. INFO.:	US 1996-621138	A	19960321
	US 1996-27127P	P	19960930
	WO 1997-US4956	W	19970319

ED Entered STN: 09 Oct 1997

AB The invention provides methods by which hyperaccumulation of metals in plant shoots, especially of Brassica, is induced by exposure to inducing agents.

In preferred embodiments, manipulations that increase availability of metals to the plant are employed prior to application of the inducing agent. Effective inducing agents include conditions of low **pH**, chelators, herbicides, and high levels of heavy metals. Other phytotoxic agents are also useful. Application of multiple inducing agents results in synergistic effects. The hyperaccumulating plants remove heavy metals from polluted soils.

IC ICM B09C001-10
ICS C02F003-32
CC 19-9 (Fertilizers, Soils, and Plant Nutrition)
ST hyperaccumulation **metal** plant shoot soil **phytoremediation**
IT Detergents

Herbicides
(agents for hyperaccumulation of **metals** in plant shoots, useful for soil **phytoremediation**)

IT Soil reclamation
(biol.; hyperaccumulation of **metals** in plant shoots, useful for soil **phytoremediation**)

IT Radiation
(effect on hyperaccumulation of **metals** in plant shoots, useful for soil **phytoremediation**)

IT Temperature effects, biological
(heat; on hyperaccumulation of **metals** in plant shoots, useful for soil **phytoremediation**)

IT **Alyssum**
Brassica
Eruca
Pennycress (Thlaspi)
Plant (Embryophyta)
(hyperaccumulation of **metals** in plant shoots, useful for soil **phytoremediation**)

IT Heavy **metals**
RL: BSU (Biological study, unclassified); REM (Removal or disposal); BIOL (Biological study); PROC (Process)
(hyperaccumulation of **metals** in plant shoots, useful for soil **phytoremediation**)

IT 50-81-7, Ascorbic acid, biological studies 60-00-4, EDTA, biological studies 62-56-6, Thiourea, biological studies 64-19-7, Acetic acid, biological studies 66-71-7D, 1,10-Phenanthroline, substituted 67-42-5, EGTA 67-43-6, DTPA 69-72-7, Salicylic acid, biological studies 77-92-9, biological studies 94-74-6, MCPA 94-75-7, 2,4-D, biological studies 95-45-4, Dimethylglyoxime 121-44-8D, substituted 123-33-1, MH 139-13-9, NTA 148-18-5, Cupral 148-25-4, Chromotropic acid 150-39-0, HEDTA 326-06-7 574-13-0, Cupron 631-61-8, Ammonium acetate 1317-37-9, Ferrous sulfide 1610-18-0, Prometon 3051-09-0, Murexide 4685-14-7, Paraquat 5910-23-6 6915-15-7, Malic acid 7647-01-0, Hydrochloric acid, biological studies 7664-93-9, Sulfuric acid, biological studies 7697-37-2, Nitric acid, biological studies 7704-34-9, Sulfur, biological studies 7720-78-7, Ferrous sulfate 7783-20-2, Ammonium sulfate, biological studies 13147-57-4, Glycophosphoric acid 13291-61-7, CDTA 38641-94-0, Roundup 196870-12-9, Rockland
RL: AGR (Agricultural use); BUU (Biological use, unclassified); BIOL (Biological study); USES (Uses)
(agent for hyperaccumulation of **metals** in plant shoots, useful for soil **phytoremediation**)

IT 7429-90-5, Aluminum, biological studies 7439-88-5, Iridium, biological studies 7439-91-0, Lanthanum, biological studies 7439-92-1, Lead, biological studies 7439-96-5, Manganese, biological studies 7439-97-6, Mercury, biological studies 7439-98-7, Molybdenum, biological studies 7440-00-8, Neodymium, biological studies **7440-02-0**, **Nickel**, biological studies 7440-05-3, Palladium, biological studies 7440-07-5, Plutonium, biological studies 7440-17-7, Rubidium, biological studies 7440-18-8, Ruthenium, biological studies 7440-22-4, Silver, biological studies 7440-24-6, Strontium, biological studies 7440-26-8, Technetium, biological studies 7440-28-0, Thallium, biological studies 7440-29-1, Thorium, biological studies 7440-31-5, Tin, biological studies 7440-34-8, Actinium, biological studies 7440-35-9, Americium, biological studies 7440-36-0, Antimony, biological studies 7440-38-2, Arsenic, biological studies 7440-39-3, Barium, biological studies 7440-41-7, Beryllium, biological studies 7440-43-9, Cadmium, biological studies 7440-45-1, Cerium, biological studies

7440-46-2, Cesium, biological studies 7440-47-3, Chromium, biological studies **7440-48-4**, **Cobalt**, biological studies 7440-50-8, Copper, biological studies 7440-51-9, Curium, biological studies 7440-53-1, Europium, biological studies 7440-57-5, Gold, biological studies 7440-61-1, Uranium, biological studies 7440-62-2, Vanadium, biological studies 7440-65-5, Yttrium, biological studies 7440-66-6, Zinc, biological studies 7440-67-7, Zirconium, biological studies 7440-74-6, Indium, biological studies 7782-49-2, Selenium, biological studies
RL: BSU (Biological study, unclassified); REM (Removal or disposal); BIOL (Biological study); PROC (Process)
(hyperaccumulation of **metals** in plant shoots, useful for soil **phytoremediation**)

L26 ANSWER 10 OF 10 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 1997:331505 HCAPLUS
DOCUMENT NUMBER: 127:80829
TITLE: The **nickel** hyperaccumulator plant **Alyssum** bertolonii as a potential agent for **phytoremediation** and **phytomining** of **nickel**
AUTHOR(S): Robinson, B. H.; Chiarucci, A.; Brooks, R. R.; Petit, D.; Kirkman, J. H.; Gregg, P. E. H.; De Dominicis, V.
CORPORATE SOURCE: Laboratoire de Genetique et Evolution, CNRS, Universite de Lille, Villeneuve d'Ascq, F-59655, Fr.
SOURCE: Journal of Geochemical Exploration (1997), 59(2), 75-86
CODEN: JGCEAT; ISSN: 0375-6742
PUBLISHER: Elsevier
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 24 May 1997
AB Expts. were carried out on the potential use of the hyperaccumulator A. bertolonii in **phytomining** of ultramafic soils for Ni. In situ exptl. plots were fertilized with various regimes during a 2-yr period. The best fertilizer treatment (N+K+P) gave a threefold increase of the biomass of reproductive matter to 9.0 ton/ha without dilution of the unfertilized Ni content. A Ni content of 0.8% in dry matter (11% in ash), would give a Ni yield of 72 kg/ha without need of resowing for a further crop. There was no correlation between the age of a plant and its Ni content. The long-term cropping sustainability of the soils was simulated by sequential extns. with K H phthalate solns. at **pH** 2, 4 and 6, that showed a limiting available Ni content of 768 μg/g. Thus, just over seven croppings at **pH** 6 in the rhizosphere would reduce the available Ni pool by 30%. A proposed model for **phytomining** involves harvesting the crop after 12 mo and burning the material to produce a sulfur-free bio-ore with about 11% Ni. Utilising the energy of combustion is also discussed. A. bertolonii or other Alyssum species might be used for **phytomining** throughout the Mediterranean area including Anatolia, as well as in Western Australia and the western United States. The economic limits of **phytomining** are proposed and at current world prices, the technique would only be feasible for Ni and Co with plants of at least the same biomass as Alyssum. Plants of higher biomass and similar uptake potential as for Ni, could extend the limits to other elements.
CC 19-9 (Fertilizers, Soils, and Plant Nutrition)
Section cross-reference(s): 53
ST **Alyssum** soil **phytoremediation phytomining** **nickel**
IT Soil reclamation

(biol.; use of **Alyssum** bertolonii for soil **phytoremediation** and **phytomining** of **nickel**)
IT **Mining**
(**phyto**-; use of **Alyssum** bertolonii for soil **phytoremediation** and **phytomining** of **nickel**)
IT **Alyssum** bertolonii
(use for soil **phytoremediation** and **phytomining** of **nickel**)
IT **7440-02-0P**, **Nickel**, preparation
RL: PUR (Purification or recovery); REM (Removal or disposal); PREP (Preparation); PROC (Process)
(use of **Alyssum** bertolonii for soil **phytoremediation** and **phytomining** of **nickel**)

L28 ANSWER 1 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2005:463748 HCAPLUS
TITLE: Salt (NaCl) tolerance in the Ni hyperaccumulator **Alyssum** murale and the Zn hyperaccumulator Thlaspi caerulescens
AUTHOR(S): Comino, Elena; Whiting, Steven N.; Neumann, Peter M.; Baker, Alan J. M.
CORPORATE SOURCE: Department of Geo-Resources and Land, Politecnico di Torino, Turin, 10129, Italy
SOURCE: Plant and Soil (2005), 270(1-2), 91-99
CODEN: PLSOA2; ISSN: 0032-079X
PUBLISHER: Springer
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 01 Jun 2005
AB Many metal hyperaccumulating plants have to tolerate abiotic stresses in their native soils such as high metal concns., low nutrient status and drought. This paper tests the ability of the Ni-hyperaccumulator Alyssum murale and two races of the Zn-hyperaccumulator Thlaspi caerulescens (Prayon and Close House) to tolerate salinity. The plants were exposed to salt (NaCl) solns. ranging between 0 mM and 100 mM in conjunction with either high or low concns. of Ni or Zn. Alyssum murale was most resistant to salt in terms of seedling emergence and survival of emerged seedlings. The two races of T. caerulescensand T. arvense were salt sensitive. High Ni or Zn concns. did not have a clear effect on the salt tolerance of any of the plants tested. The implications of the findings are discussed for the development of metal phytoremediation/**phytomining** technologies on saline soils or where brackish water (e.g., mining wastewater) could be used to irrigate phytoremediation crops'.
CC 19 (Fertilizers, Soils, and Plant Nutrition)
REFERENCE COUNT: 30 THERE ARE 30 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 2 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2005:76981 HCAPLUS
DOCUMENT NUMBER: 142:297397
TITLE: Nickel localization and response to increasing Ni soil levels in leaves of the Ni hyperaccumulator **Alyssum** murale
AUTHOR(S): Broadhurst, C. Leigh; Chaney, Rufus L.; Angle, J. Scott; Erbe, Eric F.; Maugel, Timothy K.
CORPORATE SOURCE: Animal Manure and Byproducts Laboratory, Animal and Natural Resources Institute, US Department of Agriculture Henry A. Wallace Agricultural Research

Center, Beltsville, MD, 20705, USA
SOURCE: Plant and Soil (2004), 265(1-2), 225-242
CODEN: PLSOA2; ISSN: 0032-079X
PUBLISHER: Kluwer Academic Publishers
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 28 Jan 2005
AB We have previously developed phytoremediation and **phytomining** technologies employing Alyssum Ni hyperaccumulators to quant. extract Ni from soils. Implementation of these technologies requires knowledge of Ni localization patterns for the Alyssum species/ecotypes of interest under realistic growth conditions. We investigated Ni uptake and localization in mature Alyssum murale 'Kotodesh' and 'AJ9' leaves. Seedlings were grown in a potting mix with an increasing series of NiSO4 addition (0, 5, 10, 20, 40, 80 mmol Ni kg-1), NiC4H6O4 addition (0, 5, 10, 30, 60, 90 mmol Ni kg-1), in Ni-contaminated soil from metal refining operations, and serpentine soil. Plants at Ni levels 0, 5, 10, 20 mmol kg-1 and in native soils grew normally. Plants at 40 mmol kg-1 exhibited the onset of phytotoxicity, and 60, 80, and 90 mmol kg-1 were phytotoxic, but symptoms of phytotoxicity abated within 6 mo. Cryogenic complement fractures were made from frozen hydrated samples. High-resolution scanning electron microscope (SEM) images were taken of one half. The other half was freeze-dried and examined with SEM and semi-quant. energy dispersive x-ray anal. Ni was highly concentrated in epidermal cell vacuoles and Ni and S counts showed a pos. correlation. Trichome pedicles and the epidermal tissue from which the trichome grows were primary Ni compartments, but Ni was not distributed throughout trichomes. Palisade and spongy mesophyll and guard/substomatal cells contained lesser Ni concns. but palisade mesophyll was an increasingly important compartment as Ni soil levels increased. Ni was excluded from vascular tissue and trichome rays.
CC 19-9 (Fertilizers, Soils, and Plant Nutrition)
ST **Alyssum** nickel hyperaccumulator soil bioremediation
IT Soil reclamation
(biol.; nickel uptake and localization in **Alyssum** murale)
IT Plant tissue
(mesophyll; nickel uptake and localization in **Alyssum** murale)
IT **Alyssum** murale
Guard cell
Leaf
(nickel uptake and localization in **Alyssum** murale)
IT Organ, plant
(trichome; nickel uptake and localization in **Alyssum** murale)
IT Organelle
(vacuole; nickel uptake and localization in **Alyssum** murale)
IT 7440-02-0, Nickel, biological studies
RL: BSU (Biological study, unclassified); REM (Removal or disposal); BIOL (Biological study); PROC (Process)
(nickel uptake and localization in **Alyssum** murale)
REFERENCE COUNT: 37 THERE ARE 37 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 3 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2004:790214 HCAPLUS
DOCUMENT NUMBER: 141:427379
TITLE: Simultaneous Hyperaccumulation of **Nickel**, Manganese, and Calcium in **Alyssum** Leaf Trichomes
AUTHOR(S): Broadhurst, C. Leigh; Chaney, Rufus L.; Angle, J. Scott; Maugel, Timothy K.; Erbe, Eric F.; Murphy,

Charles A.
CORPORATE SOURCE: Animal Manure and Byproducts Laboratory, Animal and Natural Resources Institute, U.S. Department of Agriculture, Beltsville, MD, 20705, USA
SOURCE: Environmental Science and Technology (2004), 38(21), 5797-5802
CODEN: ESTHAG; ISSN: 0013-936X
PUBLISHER: American Chemical Society
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 29 Sep 2004
AB We have developed com. viable phytoremediation/**phytomining** technols. employing Alyssum Ni-hyperaccumulator species to quant. extract Ni from soils. The majority of Ni is stored either in Alyssum leaf epidermal cell vacuoles or in the basal portions only of the numerous stellate trichomes. Here, we report simultaneous and region-specific localization of high levels of Ni, Mn, and Ca within Alyssum trichomes as determined by SEM/energy-dispersive x-ray anal. (SEM/EDX). Plants were grown in high-Ni soil, achieving up to 48,400 μg Ni/g in total leaf concentration; however, Ca and Mn were not enriched in the exptl. soils. The region-specific localization of hyperaccumulated Ca, Mn, and Ni occurred in three soil types, five Alyssum species/ecotypes, and over a wide range of soil Ni concns. The metal concentration in the trichome basal compartment was .apprx.15-20% dry weight, the highest ever reported for healthy vascular plant tissue.
CC 60-4 (Waste Treatment and Disposal)
Section cross-reference(s): 11, 19, 54
ST hyperbioaccumulation simultaneous **nickel** manganese calcium **Alyssum** leaf trichome; **phytoremediation nickel** manganese calcium hyperbioaccumulation **Alyssum** leaf trichome; **phytomining metal** hyperbioaccumulation **Alyssum** leaf trichome
IT Leaf
(**Alyssum** species; simultaneous hyperaccumulation of **metals Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
IT Water pollution
(aquifer, **phytoremediation** of; simultaneous hyperaccumulation of **metals Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
IT Soil reclamation
(biol., **phytoremediation**; simultaneous hyperaccumulation of **metals Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
IT Soils
(contaminated, **phytoremediation** of; simultaneous hyperaccumulation of **metals Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
IT X-ray spectroscopy
(energy-dispersive; in determination of simultaneous hyperaccumulation of **metals Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
IT Bioaccumulation
(hyper-; simultaneous hyperaccumulation of **metals Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
IT Scanning electron microscopy
(in determination of simultaneous hyperaccumulation of **metals Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)

IT **Mining**
(**phyto**-; simultaneous hyperaccumulation of **metals** **Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
IT Groundwater pollution
Soil pollution
(**phytoremediation** of; simultaneous hyperaccumulation of **metals Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
IT Remediation
(**phytoremediation**; simultaneous hyperaccumulation of **metals Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
IT Heavy **metals**
RL: PUR (Purification or recovery); REM (Removal or disposal); PREP (Preparation); PROC (Process)
(simultaneous hyperaccumulation of **metals Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
IT Heavy **metals**
RL: PUR (Purification or recovery); REM (Removal or disposal); PREP (Preparation); PROC (Process)
(toxicity; simultaneous hyperaccumulation of **metals** **Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
IT Organ, plant
(trichome, **Alyssum** species; simultaneous hyperaccumulation of **metals Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
IT Biological transport
(uptake; simultaneous hyperaccumulation of **metals** **Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
IT Plant tissue
(vascular; simultaneous hyperaccumulation of **metals** **Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
IT 7439-95-4P, Magnesium, processes 7439-96-5P, Manganese, processes **7440-02-0P**, **Nickel**, processes 7440-50-8P, Copper, processes 7440-66-6P, Zinc, processes 7440-70-2P, Calcium, processes
RL: PUR (Purification or recovery); REM (Removal or disposal); PREP (Preparation); PROC (Process)
(simultaneous hyperaccumulation of **metals Alyssum** Leaf Trichomes in relation to **phytoremediation** and **phytomining**)
REFERENCE COUNT: 24 THERE ARE 24 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 4 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2004:332467 HCAPLUS
DOCUMENT NUMBER: 141:126630
TITLE: Production of nickel bio-ore from hyperaccumulator plant biomass: applications in **phytomining**
AUTHOR(S): Boominathan, Rengasamy; Saha-Chaudhury, N. M.; Sahajwalla, Veena; Doran, Pauline M.
CORPORATE SOURCE: School of Biotechnology and Biomolecular Sciences, University of New South Wales, Sydney, 2052, Australia
SOURCE: Biotechnology and Bioengineering (2004), 86(3), 243-250
CODEN: BIBIAU; ISSN: 0006-3592

PUBLISHER: John Wiley & Sons, Inc.
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 23 Apr 2004
AB An important step in **phytomining** operations is the recovery of metal from harvested plant material. A laboratory-scale horizontal tube furnace was used to generate Ni-enriched bio-ore from the dried biomass of Ni hyperaccumulator plants. Prior to furnace treatment, hairy roots of Alyssum bertolonii were exposed to Ni in liquid medium to give biomass Ni concns. of 1.9-7.7% dry weight Whole plants of Berkheya coddii were grown in Ni-containing soil to produce above-ground Ni levels of ≤0.49% dry weight The concentration of Ca in the Ni-treated B. coddii biomass was about 15 times greater than that in A. bertolonii. After furnace treatment at 1200° under air, Ni-bearing residues with a crystalline morphol. and containing ≤82% Ni were generated from A. bertolonii. The net weight loss in the furnace and the degree of concentration of Ni were significantly decreased when the furnace was purged with nitrogen. This reflects the importance of oxidative processes in Ni enrichment. Ni in the B. coddii biomass was concentrated by a factor of .apprx.17 to yield a residue containing 8.6% Ni. This bio-ore Ni content is substantially higher than the 1-2% Ni typically found in mined ore. However, the B. coddii samples after furnace treatment also contained .apprx.34% Ca, mainly in the form of hydroxyapatite Ca5(PO4)3OH. Such high Ca levels may present significant challenges for further metallurgical processing. The feasibility of furnace treatment for generating Ni-rich bio-ore from hyperaccumulator plants is demonstrated. Minimizing the uptake of Ca and/or reducing the Ca content of the biomass prior to furnace treatment is a worthwhile strategy for improving the quality of Ni bio-ore produced in **phytomining** operations.
CC 54-1 (Extractive Metallurgy)
ST nickel ore prodn **phytomining** hyperaccumulator plant biomass
IT **Alyssum** bertolonii
Berkheya coddii
Mining
Vegetable materials
(production of nickel bio-ore from hyperaccumulator plant biomass by **phytomining**)
IT Nickel ores
RL: CPS (Chemical process); PEP (Physical, engineering or chemical process); PUR (Purification or recovery); PREP (Preparation); PROC (Process)
(production of nickel bio-ore from hyperaccumulator plant biomass by **phytomining**)
IT 7440-70-2, Calcium, processes
RL: CPS (Chemical process); PEP (Physical, engineering or chemical process); REM (Removal or disposal); PROC (Process)
(in production of nickel bio-ore from hyperaccumulator plant biomass by **phytomining**)
REFERENCE COUNT: 33 THERE ARE 33 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 5 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2004:144885 HCAPLUS
DOCUMENT NUMBER: 141:177252
TITLE: Investigation of genus **Alyssum** species for control and optimization of **nickel phytoextraction** processes and

phytoremediation of **nickel** contaminated soils

AUTHOR(S): Hasko, A.; Cullaj, A.; Kongoli, F.
CORPORATE SOURCE: Department of Agronomy, Agricultural University of Tirana, Albania

SOURCE: Modeling, Control and Optimization in Ferrous and Nonferrous Industry, Proceedings of the Symposium held at the Materials Science & Technology Conference, Chicago, IL, United States, Nov. 9-12, 2003 (2003), 91-104. Editor(s): Kongoli, Florian; Thomas, Brian G.; Sawamiphakdi, Krich. Minerals, Metals & Materials Society: Warrendale, Pa.
CODEN: 69FCE4; ISBN: 0-87339-561-1
DOCUMENT TYPE: Conference
LANGUAGE: English
ED Entered STN: 23 Feb 2004

AB Phytoremediation is a low cost alternative technique for remediation of contaminated soils from heavy metals that are emitted by ferrous and nonferrous mining and extracting processes. It is based on the possibility to use several plants that accumulate high level of metals to remove metal pollutants from soils and render them harmless. Phytoextn. is an adjacent technique that uses these hyper-accumulator plants to extract the metals from soil and then use conventional smelting or refining processes. Five taxa from the Alyssum genus specie had the highest ability to accumulate nickel with concns. >10,000 μg/g (dry weight) or 1%. The taxa showing the highest accumulation of Ni is Alyssum murale var. chlorocarpum with 28,600 μg/g or 2.86%, a candidate for phytoextn. To optimize the phytoremediation and phytoextn. processes further, absorption spectrometry measurements and biol. studies were carried out to determine the parts of the plants that accumulate the highest amount of nickel and the best biol. cycle during which they accumulate the highest amount The greatest accumulation of nickel occurred in the leaf (2.86%) and the least in the roots (0.43%). The investigation of the biol. cycle of the genus Alyssum showed that (1) the seeds germinated at 5-30° and more at 25° (2) 62.9% of the seeds germinated at A.m. var. chlorocarpum (3) the emergence is almost continue from Mar. to Apr. (4) the anthesis occurs from May to July (5) ripening of the fruit takes place 30 days after flowering (6) the dissemination of fruits occurs from Sept. to Oct. The Alyssum murale var. chlorocarpum, as a nickel hyperaccumulator, is the most promising plant for phytoremediation and phytoextn. purposes.

CC 54-2 (Extractive Metallurgy)
Section cross-reference(s): 19, 60
ST genus **Alyssum** optimization **nickel phytoextn** soil remediation

IT **Alyssum**
Optimization
(genus **Alyssum** species for control and optimization of **Ni phytoextn.** and **phytoremediation** of **Ni**-contaminated soils)

IT **Extraction**
(**phyto**-; genus **Alyssum** species for control and optimization of **Ni phytoextn.** and **phytoremediation** of **Ni**-contaminated soils)

IT Remediation
(**phytoremediation**; genus **Alyssum** species for control and optimization of **Ni phytoextn.** and **phytoremediation** of **Ni**-contaminated soils)

IT **7440-02-0P**, **Nickel**, preparation
RL: CPS (Chemical process); PEP (Physical, engineering or chemical process); PUR (Purification or recovery); REM (Removal or disposal); PREP

(Preparation); PROC (Process)
(genus **Alyssum** species for control and optimization of **Ni phytoextn.** and **phytoremediation** of **Ni**-contaminated soils)
REFERENCE COUNT: 4 THERE ARE 4 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 6 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2003:981336 HCAPLUS
DOCUMENT NUMBER: 140:291774
TITLE: Analysis of serpentinophytes from north-east of Portugal for trace **metal** accumulation--relevance to the management of mine environment
AUTHOR(S): Freitas, H.; Prasad, M. N. V.; Pratas, J.
CORPORATE SOURCE: Departamento de Botanica, Faculdade de Ciencias e Tecnologia, Universidade de Coimbra, Coimbra, 3000, Port.
SOURCE: Chemosphere (2004), 54(11), 1625-1642
CODEN: CMSHAF; ISSN: 0045-6535
PUBLISHER: Elsevier Science Ltd.
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 17 Dec 2003
AB In north-east of Portugal, the serpentinized area is about 8000 ha with a characteristic geol. and flora. The serpentine plant community and resp. soils were analyzed to examine the trace metal budget in different tissues of the plants exhibiting resistance to trace metals. One hundred and thirty five plant species belonging to 39 families and resp. soils have been analyzed for total Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn. Substantial amts. of Ni, Cr, Co and Mn were detected in plant tissues which are listed below: Ni: Alyssum serpyllifolium (38 105); Bromus hordeaceus (1467); Linaria spartea (492); Plantago radicata (140); Lavandula stoechas (118) and Cistus salvifolius (114); Cr: L. spartea (706.7); Ulmus procera (173.4); A. serpyllifolium (129.3); Cistus ladanifer (40.8); L. stoechas (29.5); P. radicata (27.81); Setariopsis verticillata (25.7); Plantago lanceolata (24); Digitalis purpurea (23.4); Logfia min. (23.1); Arenaria querioides (23); Hieracium peleteranum (22.7); Arenaria montana (14.5); Co: A. serpyllifolium (145.1); L. spartea (63.2); P. radicata (10.4); H. peleteranum (7.3); Lepidium heterophyllum (6.9); A. querioides (6.6); C. salvifolius (6.5); C. ladanifer (6.3); L. stoechas (6.1); Anthyllis lotoides (6.1); L. min. (6.1); Euphorbia falcata (5.7) and B. hordeaceus (5.6); Mn: A. serpyllifolium (830); L. spartea (339); L. stoechas (187.1); L. min. (182.7); Castanea sativa (125); Spergula pentandra (124); P. radicata (119); Cytisus striatus (115.4); Quercus pyrenaica (110); Teucrium scorodonia (109.4); Fraxinus vulgaris (109); Anthyllis sampaiana (108); Quercus ilex (108). The significance of serpentine flora, need for conservation of these fragile and environmentally invaluable plant resources for possible use for in situ remediation of metalliferous substrates are presented in this paper.
CC 60-4 (Waste Treatment and Disposal)
Section cross-reference(s): 11, 19
ST **phytoremediation** serpentinophyte northeast Portugal trace **metal** contaminated mine soil; serpentinophyte northeast Portugal trace **metal** bioaccumulation management mine environment
IT Remediation
(bioremediation; trace **metal** accumulation of serpentinophytes from northeastern Portugal for bioremediation and management of mine environment)
IT Soils

(contaminated; trace **metal** accumulation of serpentinophytes from northeastern Portugal for bioremediation and management of mine environment)

IT Soils
(serpentine; trace **metal** accumulation of serpentinophytes from northeastern Portugal for bioremediation and management of mine environment)

IT Embryophyta
(serpentinophytes; trace **metal** accumulation of serpentinophytes from northeastern Portugal for bioremediation and management of mine environment)

IT **Alyssum** serpyllifolium
Anthyllis
Anthyllis lotoides
Arenaria
Bioaccumulation
Bromus hordeaceus
Castanea sativa
Cistus ladanifer
Cistus salviifolius
Cytisus striatus
Digitalis purpurea
Euphorbia falcata
Fraxinus
Hieracium peleterianum
Lavandula stoechas
Lepidium heterophyllum
Linaria
Plantago
Plantago lanceolata
Quercus ilex
Quercus pyrenaica
Spergula
Teucrium scorodonia
Ulmus procera
(trace **metal** accumulation of serpentinophytes from northeastern Portugal for bioremediation and management of mine environment)

IT Trace **metals**
RL: BSU (Biological study, unclassified); POL (Pollutant); BIOL (Biological study); OCCU (Occurrence)
(trace **metal** accumulation of serpentinophytes from northeastern Portugal for bioremediation and management of mine environment)

IT 7439-89-6, Iron, biological studies 7439-92-1, Lead, biological studies 7439-96-5, Manganese, biological studies **7440-02-0**, **Nickel**, biological studies 7440-47-3, Chromium, biological studies **7440-48-4**, **Cobalt**, biological studies 7440-50-8, Copper, biological studies 7440-66-6, Zinc, biological studies
RL: BSU (Biological study, unclassified); POL (Pollutant); BIOL (Biological study); OCCU (Occurrence)
(trace **metal** accumulation of serpentinophytes from northeastern Portugal for bioremediation and management of mine environment)

REFERENCE COUNT: 39 THERE ARE 39 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 7 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2003:615102 HCAPLUS

DOCUMENT NUMBER: 140:13860
TITLE: Spread of metals through an invertebrate food chain as influenced by a plant that hyperaccumulates nickel
AUTHOR(S): Peterson, Lynsey R.; Trivett, Victoria; Baker, Alan J. M.; Aguiar, Carlos; Pollard, A. Joseph
CORPORATE SOURCE: Department of Biology, Furman University, Greenville, SC, 29613, USA
SOURCE: Chemoecology (2003), 13(2), 103-108
CODEN: CHMOE9; ISSN: 0937-7409
PUBLISHER: Birkhaeuser Verlag
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 12 Aug 2003
AB Hyperaccumulation of metals in the shoot system of plants is uncommon, yet taxonomically and geog. widespread. It may have a variety of functions, including defense against herbivores. This study investigated the effects of hyperaccumulation on metal concns. across trophic levels. The authors collected plant material, soil, and invertebrates from Portuguese serpentine outcrops whose vegetation is dominated by the nickel hyperaccumulator Alyssum pintodasilvae. Samples were analyzed for nickel, chromium, and cobalt. Grasshoppers, spiders, and other invertebrates collected from sites where A. pintodasilvae was common had significantly elevated concns. of nickel, compared to nearby sites where this hyperaccumulator was not found. Chromium and cobalt, occurring in high concns. in the serpentine soil but not accumulated by A. pintodasilvae, were not elevated in the invertebrates. Therefore, it appears likely that a flux of nickel to herbivore and carnivore trophic levels is specifically facilitated by the presence of plants that hyperaccumulate this metal. The results may be relevant to the development of phytoremediation and **phytomining** technologies, which use plants to extract metals from the soil.
CC 4-3 (Toxicology)
ST nickel hyperaccumulation **Alyssum** invertebrate food chain
IT **Alyssum** pintodasilvae
Araneae
Food chain
Grasshopper
Invertebrata
Soils
(spread of metals through an invertebrate food chain as influenced by a plant that hyperaccumulates nickel)
REFERENCE COUNT: 35 THERE ARE 35 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 8 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2003:397511 HCAPLUS
DOCUMENT NUMBER: 139:307270
TITLE: The potential of several plants for **phytoremediation** of **nickel** contaminated soils and for **nickel phytoextraction**
AUTHOR(S): Cullaj, A.; Hasko, A.; Kongoli, F.
CORPORATE SOURCE: Department of Chemistry, University of Tirana, Tirane, Albania
SOURCE: Metallurgical and Materials Processing: Principles and Technologies, Yazawa International Symposium, San Diego, CA, United States, Mar. 2-6, 2003 (2003), Volume 2, 575-585. Editor(s): Kongoli, Florian. Minerals, Metals & Materials Society: Warrendale, Pa.
CODEN: 69DYBN; ISBN: 0-87339-534-4

DOCUMENT TYPE: Conference
LANGUAGE: English
ED Entered STN: 25 May 2003
AB Several industrial sites suffer from the contamination of soils from heavy metals, which are emitted among others by anthropogenic mining and metallurgical activities. Effective and economic physicochem. technologies for remediation of these sites remain complicated and costly. A new alternative remediation technique is the so-called phytoremediation. This is based on the ability of some plants to accumulate very high concns. of metals from soils and thus providing the basis for a remediation of the contaminated sites. This technique as an emerging branch of natural biotechnol., has several advantages compared to the sophisticated physicochem. techniques of soil remediation. It is not only environmentally friendly but also its costs are quite low since it is solar driven. Furthermore plants can accumulate metals to such levels that the mineral recovery maybe feasible even in conventional Ni refinery or smelting operations. In this work, the potential of many plants to accumulate Ni was investigated to identify the species which offer the best phytoremedial potential for Ni contaminated soils in Albania. Field surveys were made in 5 Ni-containing sites to identify the Ni tolerant species that have spontaneously grown in contaminated soils. Atomic Absorption Spectrometry measurements were carried out on 145 different plants collected. 16 Of them were identified as having an hyper ability to accumulate Ni since they contained more than 10 000 mg Ni per kg (DW). Seven taxa are of Alyssum genus and one of Bornmuellera genus of Cruciferae. The highest accumulation of Ni was present in aerial parts of Alyssum murale var. chlorocarpum Hausskn (25 500 mg/kg or 2.5%) and Alyssum markgrafii O.E. Schulz (23 700 mg/kg or 2.37%). The seeds germinated are more evidenced at A.m.var. chlorocarpum, about 63%. These plants are suggested as the most promising species to be used for phytoremediation purposes in Ni contaminated soils and phytoextn. of Ni.
CC 19-9 (Fertilizers, Soils, and Plant Nutrition)
ST soil contamination **nickel phytoremediation** **Alyssum**
IT Remediation
(**phytoremediation**; potential of several plants for **phytoremediation** of **Ni** contaminated soils and for **Ni phytoextn.**)
IT **Alyssum** argenteum
Alyssum baldacii
Alyssum markgrafii
Alyssum murale
Bioaccumulation
(potential of several plants for **phytoremediation** of **Ni** contaminated soils and for **Ni phytoextn** .)
IT **Alyssum** bertolonii
(subsp. scutarinum; potential of several plants for **phytoremediation** of **Ni** contaminated soils and for **Ni phytoextn.**)
IT 7439-95-4, Magnesium, occurrence **7440-48-4**, **Cobalt**, occurrence 7440-70-2, Calcium, occurrence
RL: OCU (Occurrence, unclassified); OCCU (Occurrence)
(potential of several plants for **phytoremediation** of **Ni** contaminated soils and for **Ni phytoextn** .)
IT **7440-02-0**, **Nickel**, occurrence
RL: POL (Pollutant); REM (Removal or disposal); OCCU (Occurrence); PROC (Process)
(potential of several plants for **phytoremediation** of

Ni contaminated soils and for **Ni phytoextn**
.)
REFERENCE COUNT: 12 THERE ARE 12 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 9 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2003:350644 HCAPLUS
DOCUMENT NUMBER: 139:104330
TITLE: **Nickel** mining - a growth industry
AUTHOR(S): Hill, Steve
CORPORATE SOURCE: UK
SOURCE: Materials World (2003), 11(4), 20-22
CODEN: MORLEE; ISSN: 0967-8638
PUBLISHER: IOM Communications Ltd.
DOCUMENT TYPE: Journal; General Review
LANGUAGE: English
ED Entered STN: 08 May 2003
AB A review. Inco and Viridian Resources has developed a new way of extracting nickel from the ground. Known as **phytomining**, the new process uses special varieties of hyperaccumulator plants to selectively extract metals from soil, so concentrating the metals for downstream processing in a traditional smelter. Recent trials indicate that **phytomining** could be com. feasible, either as an auxiliary process to conventional mining, or potentially as a stand-alone mining operation.
CC 56-0 (Nonferrous Metals and Alloys)
Section cross-reference(s): 53
ST review **phytomining nickel** mining **metal** extn soil **Alyssum phytoremediation**
IT Embryophyta
Mining
Soils
(**phytomining** of **nickel** ores to selectively extract the **metal** by plants)
IT **Nickel** ores
RL: GOC (Geological or astronomical occurrence); PRP (Properties); OCCU (Occurrence)
(**phytomining** of **nickel** ores to selectively extract the **metal** by plants)

L28 ANSWER 10 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2002:199789 HCAPLUS
DOCUMENT NUMBER: 137:37033
TITLE: An evaluation of Berkheya coddii roessler and **Alyssum** bertolonii Desv. for **phytoremediation** and **phytomining** of **nickel**
AUTHOR(S): Brooks, R. R.; Robinson, B. H.; Howes, A. W.; Chiarucci, A.
CORPORATE SOURCE: Soil and Earth Sciences, Institute of Natural Resources, Massey University, Palmerston North, N. Z.
SOURCE: South African Journal of Science (2001), 97(11/12, Pt. 2), 558-560
CODEN: SAJSAR; ISSN: 0038-2353
PUBLISHER: National Research Foundation
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 19 Mar 2002
AB This paper includes field and pot trials carried out on the Ni-hyperaccumulator plants Alyssum bertolonii (from Italy) and Berkheya coddii (from South Africa), and their potential use for phytoremediation

(removal of pollutants from soils) and **phytomining**, growing a crop of Ni. Fertilization of wild plants of A. bertolonii in Italy increased the biomass by a factor of 3, to give a yield of 9 tons/ha without consequent reduction of the Ni concentration of 7000 mg/Kg dry mass. This species can thus be used for phytoremediation of soils lightly polluted with Ni. Analogous expts. with B. coddii gave a fertilized dry biomass of 22 tons/ha with 5000 mg/Kg Ni in dry biomass. This species would need only half the number of crops required for A. bertolonii to remediate weakly polluted soils. A single crop of B. coddii could remove .apprx.110 Kg/ha of Ni (worth US$579 in Nov. 2001) compared with 63 Kg/ha by A. bertolonii, worth $331. Assuming that only half of the value of the Ni was returned to the grower, the **phytomining** operation could be potentially economic for B. coddii but not for A. bertolonii. Sale of the energy derived from combustion of the biomass could improve the economics, but only in the case of a large-scale operation. It is proposed that the economics of **phytomining** could be improved by selective breeding of plants with greater biomass and higher metal concns. as well as by transferring the hyperaccumulating gene to plants of large natural biomass.

CC 60-4 (Waste Treatment and Disposal)
Section cross-reference(s): 19

ST Berkheya **Alyssum phytoremediation phytomining nickel**

IT **Alyssum** bertolonii
Berkheya coddii
(Berkheya coddii and **Alyssum** bertolonii for **phytoremediation** and **phytomining** of **nickel**)

IT Soil reclamation
(biol.; Berkheya coddii and **Alyssum** bertolonii for **phytoremediation** and **phytomining** of **nickel**)

IT **7440-02-0**, **Nickel**, processes
RL: REM (Removal or disposal); PROC (Process)
(Berkheya coddii and **Alyssum** bertolonii for **phytoremediation** and **phytomining** of **nickel**)

REFERENCE COUNT: 21 THERE ARE 21 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 11 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2001:82687 HCAPLUS
DOCUMENT NUMBER: 134:310568
TITLE: Assessing plant **phytoextraction** potential through mathematical modeling
AUTHOR(S): Gonnelli, Cristina; Marsili-Libelli, Stefano; Baker, Alan; Gabbrielli, Roberto
CORPORATE SOURCE: Department of Plant Biology, University of Florence, Florence, 50121, Italy
SOURCE: International Journal of Phytoremediation (2000), 2(4), 343-351
CODEN: IJPHFG; ISSN: 1522-6514
PUBLISHER: CRC Press LLC
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 05 Feb 2001
AB One of the most serious and long-term consequences of environmental pollution is heavy metal contamination of soils. Elements such as zinc, cadmium, lead, nickel, and chromium are being released into the environment by many industrial processes and have now reached concns. that are of concern. Phytoremediation is a new, low-cost, and environmentally friendly technique that relies on the natural properties of some plants to

clean-up the ground through their ability to take up metals from the soil. Hyperaccumulator plants, capable of accumulating metals far in excess of any normal physiol. requirement, represent a most promising tool for metal phytoextn., but the in field establishment of their conditions for utilization needs a long period because of the plant life-cycle. The use of a math. model is proposed to process growth and uptake data from in vitro expts. for a rapid assessment of the time and concentration parameters for the deployment of hyperaccumulator plants for phytoextn. purposes. This preliminary research has been carried out using Alyssum bertolonii Desv., a nickel hyperaccumulator endemic to Italian serpentine soils.

CC 19-9 (Fertilizers, Soils, and Plant Nutrition)

ST soil **phytoremediation** heavy **metal** model

IT **Alyssum** bertolonii

IT Soil pollution
(assessment of **phytoremediation** of heavy **metal** -contaminated soils through math. modeling)

IT Heavy **metals**
RL: POL (Pollutant); OCCU (Occurrence)
(assessment of **phytoremediation** of heavy **metal** -contaminated soils through math. modeling)

IT Simulation and Modeling, biological
(assessment of plant **phytoextn.** potential through math. modeling)

IT Soil reclamation
(biol., **phytoremediation**; assessment of **phytoremediation** of heavy **metal**-contaminated soils through math. modeling)

IT 7439-92-1, Lead, occurrence **7440-02-0, Nickel**, occurrence 7440-43-9, Cadmium, occurrence 7440-47-3, Chromium, occurrence 7440-66-6, Zinc, occurrence
RL: POL (Pollutant); OCCU (Occurrence)
(assessment of **phytoremediation** of heavy **metal** -contaminated soils through math. modeling)

REFERENCE COUNT: 19 THERE ARE 19 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 12 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN

ACCESSION NUMBER: 2000:846050 HCAPLUS

DOCUMENT NUMBER: 134:127004

TITLE: Assessment of **metal** accumulation in plants using MetPAD, a toxicity test specific for heavy **metal** toxicity

AUTHOR(S): Boularbah, Ali; Bitton, Gabriel; Morel, Jean Louis; Schwartz, Christophe

CORPORATE SOURCE: Department of Biology, Faculte des Sciences et Techniques, Universite Cadi Ayyad, Marrakech, Morocco

SOURCE: Environmental Toxicology (2000), 15(5), 449-455
CODEN: ETOXFH; ISSN: 1520-4081

PUBLISHER: John Wiley & Sons, Inc.

DOCUMENT TYPE: Journal

LANGUAGE: English

ED Entered STN: 05 Dec 2000

AB Heavy metal contamination of soils is wide spread and concerns have been raised over the potential risks to humans, animals, and agricultural crops. Toxic metals are readily accumulated in some plants and may pose a threat to humans and grazing animals. The discovery of metal-hyperaccumulating plants (i.e., metallophytes) has led to phytoremediation, a soil cleanup technol. consisting of using metallophytes to remove metals from contaminated soils. The authors'

study concerns the development of a test, hereafter called MetPLANT, for assessing metal accumulation or hyperaccumulation in plants growing on contaminated soils. MetPLANT consists of extracting metals from the plant followed by the determination of heavy metal toxicity, using MetPAD. The toxicity tests were run concurrently with chemical anal. of metals in plants and exts. The test was used to assess metal contamination of plants growing in a raw wastewater application site located in Marrakech, Morocco, and in metal-contaminated sites (mining areas and industrially contaminated soils) located in France and Albania. It was observed that zinc (up to 17,691 mg/kg) and nickel (up to 12,625 mg/kg) were the metals most accumulated in the plants. The general trend observed was an increase in metal toxicity as the total metal content of the plants or the metal content of the plant exts. increased. This simple test can be used to rapidly assess metal accumulation in plants and could be useful in phytoremediation sites for determining the potential of plants to remediate metal-contaminated soils.

CC 4-3 (Toxicology)
Section cross-reference(s): 11

ST heavy **metal** toxicity bioaccumulation plant

IT **Alyssum** markgrafii
Alyssum murale
Armeria maritima
Arrhenatherum elatius
Arundo donax
Atriplex halimus
Bermuda grass
Cardaminopsis halleri
Carex divisa
Corn
Datura stramonium
Euphorbia myrsinites
Olive
Pennycress (Thlaspi caerulescens)
Soil pollution
(assessment of **metal** accumulation in plants using MetPAD, a toxicity test specific for heavy **metal** toxicity)

IT Remediation
(bioremediation, **phytoremediation**; assessment of **metal** accumulation in plants using MetPAD, a toxicity test specific for heavy **metal** toxicity)

IT Environmental pollution
(heavy **metal**; assessment of **metal** accumulation in plants using MetPAD, a toxicity test specific for heavy **metal** toxicity)

IT Heavy **metals**
RL: ADV (Adverse effect, including toxicity); POL (Pollutant); BIOL (Biological study); OCCU (Occurrence)
(toxicity; assessment of **metal** accumulation in plants using MetPAD, a toxicity test specific for heavy **metal** toxicity)

IT 7439-92-1, Lead, biological studies **7440-02-0**, **Nickel**, biological studies 7440-43-9, Cadmium, biological studies 7440-47-3, Chromium, biological studies **7440-48-4**, **Cobalt**, biological studies 7440-50-8, Copper, biological studies 7440-66-6, Zinc, biological studies
RL: ADV (Adverse effect, including toxicity); BOC (Biological occurrence); BSU (Biological study, unclassified); POL (Pollutant); BIOL (Biological study); OCCU (Occurrence)
(assessment of **metal** accumulation in plants using MetPAD, a toxicity test specific for heavy **metal** toxicity)

REFERENCE COUNT: 13 THERE ARE 13 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 13 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2000:296596 HCAPLUS
DOCUMENT NUMBER: 132:312802
TITLE: Characteristics of heavy **metal** uptake by plant species with potential for **phytoremediation** and **phytomining**
AUTHOR(S): Nedelkoska, T. V.; Doran, P. M.
CORPORATE SOURCE: Department of Biotechnology, University of New South Wales, Sydney, 2052, Australia
SOURCE: Minerals Engineering (2000), 13(5), 549-561
CODEN: MENGEB; ISSN: 0892-6875
PUBLISHER: Elsevier Science Ltd.
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 09 May 2000
AB Genetically transformed hairy root cultures were established for a range of plant species and applied in studies of growth and accumulation of heavy metals. Expts. were conducted using a liquid nutrient medium containing elevated concns. of Ni, Cd, or Cu. Hairy roots of three hyperaccumulator species were tested for Ni uptake; of these, Alyssum bertolonii accumulated the highest Ni contents in the biomass after exposure to 20 ppm Ni for up to 9 h. Ni uptake was relatively slow, with 5-7 h required to achieve equilibrium conditions, suggesting the involvement of intracellular processes in Ni accumulation and(or) detoxification. In contrast, the uptake of Cd and Cu by hairy roots of several hyperaccumulator and nonhyperaccumulator species was fast, with equilibrium conditions achieved after only 30-60 min. Cd uptake during the first 9 h of exposure was increased by treatment with H+-ATPase inhibitor and was similar in live and autoclaved roots, suggesting that Cd uptake was due, at least initially, to sorptive rather than intracellular mechanisms. Up to 10,600 μg Cd/g dry weight was accumulated by growing Thlaspi caerulescens hairy roots from a liquid-phase concentration of 100 ppm. In contrast, growth of Nicotiana tabacum hairy roots was severely retarded at 20 ppm Cd and negligible at 100 ppm. Similar Cu levels were accumulated by Hyptis capitata, Polycarpaea longiflora, and N. tabacum hairy roots after short-term exposure to 1000 ppm Cu; under the same conditions, the Cu content in Euphorbia hirta hairy roots was 28% lower. Growth of H. capitata roots was slightly reduced in the presence of EDTA, but was unaffected by addition of both EDTA and 20 ppm Cu to the medium. This work demonstrates the utility of hairy roots for screening a range of plant species for their biosorption and long-term metal uptake capabilities.
CC 60-1 (Waste Treatment and Disposal)
ST heavy **metal** uptake plant hairy root **phytoremediation** **phytomining** potential; biosorption heavy **metal** uptake plant hairy root wastewater treatment
IT Wastewater treatment
(biosorption; characteristics of heavy **metal** uptake by plant species with potential for **phytoremediation** and **phytomining**)
IT Heavy **metals**
RL: BPR (Biological process); BSU (Biological study, unclassified); REM (Removal or disposal); BIOL (Biological study); PROC (Process)
(characteristics of heavy **metal** uptake by plant species with potential for **phytoremediation** and **phytomining**)
IT Tumor, plant
(hairy root; characteristics of heavy **metal** uptake by plant species with potential for **phytoremediation** and

phytomining)
IT Wastewater treatment
(macrophytic; characteristics of heavy **metal** uptake by plant species with potential for **phytoremediation** and **phytomining**)
IT **Mining**
(**phyto**-; characteristics of heavy **metal** uptake by plant species with potential for **phytoremediation** and **phytomining**)
IT Agrobacterium rhizogenes
(plant hair root infection by; characteristics of heavy **metal** uptake by plant species with potential for **phytoremediation** and **phytomining**)
IT **Alyssum** bertolonii
Alyssum tenium
Alyssum troodii
Euphorbia hirta
Hyptis capitata
Pennycress (Thlaspi caerulescens)
Polycarpaea longiflora
Tobacco
(with hairy roots; characteristics of heavy **metal** uptake by plant species with potential for **phytoremediation** and **phytomining**)
IT **7440-02-0**, **Nickel**, processes 7440-43-9, Cadmium, processes 7440-50-8, Copper, processes
RL: BPR (Biological process); BSU (Biological study, unclassified); PEP (Physical, engineering or chemical process); REM (Removal or disposal); BIOL (Biological study); PROC (Process)
(characteristics of heavy **metal** uptake by plant species with potential for **phytoremediation** and **phytomining**)
IT 60-00-4, Glycine, N,N'-1,2-ethanediylbis[N-(carboxymethyl)-, miscellaneous
RL: MSC (Miscellaneous)
(characteristics of heavy **metal** uptake by plant species with potential for **phytoremediation** and **phytomining**)
REFERENCE COUNT: 42 THERE ARE 42 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 14 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2000:196018 HCAPLUS
DOCUMENT NUMBER: 132:269414
TITLE: Enhancement of **Phytoextraction** of Zn, Cd, and Cu from Calcareous Soil: The Use of NTA and Sulfur Amendments
AUTHOR(S): Kayser, A.; Wenger, K.; Keller, A.; Attinger, W.; Felix, H. R.; Gupta, S. K.; Schulin, R.
CORPORATE SOURCE: Institute of Terrestrial Ecology, Swiss Federal Institute of Technology, Schlieren, CH-8952, Switz.
SOURCE: Environmental Science and Technology (2000), 34(9), 1778-1783
CODEN: ESTHAG; ISSN: 0013-936X
PUBLISHER: American Chemical Society
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 28 Mar 2000
AB In a field experiment we investigated the efficiency of two hyperaccumulating species, four agricultural crop plants, and one woody crop, at phytoextn. of Zn, Cd, and Cu from a polluted calcareous soil. In addition, we examined the possibility to enhance the phytoextn. of these metals by application of nitrilotriacetate (NTA) and elemental sulfur (S8) to the soil. Metal

uptake by hyperaccumulating species was higher than that by crop species but was generally low in all treatments compared to results reported in the literature, maybe as a result of lower total and available soil metal concns. Soil amended with either S8 or NTA increased the solubility (NaNO3-extraction) of Zn, Cd, and Cu ions by factors of 21, 58, and 9, resp., but plant accumulation of these metals was only increased by a factor of 2-3. As a result, even the highest metal removal rates achieved in this study were still far from what would be required to make this technique practicable for the remediation of the Dornach field site. To extract for example 50% of the total Cu, Zn, or Cd present in this soil within 10 yr, plant metal concns. of 10.000 mg kg-1 Cu or 10.000 mg kg-1 Zn or 45 mg kg-1 Cd would be required at a biomass production of 7.8 t ha-1, or 10 t ha-1, or 10 t ha-1, resp., assuming a linear decrease in soil metals.

CC 60-4 (Waste Treatment and Disposal)
Section cross-reference(s): 11, 19

ST nitrilotriacetate sulfur heavy **metal** solubilization **phytoextn** soil remediation

IT Extraction
(**phytoextn.**; use of nitrilotriacetate and sulfur amendments in enhancement of **phytoextn.** of Zn, Cd, and Cu from calcareous soil)

IT **Alyssum** murale
Brassica juncea
Corn
Pennycress (Thlaspi caerulescens)
Soil reclamation
Solubilization
Sunflower
Tobacco
Willow (Salix viminalis)
(use of nitrilotriacetate and sulfur amendments in enhancement of **phytoextn.** of Zn, Cd, and Cu from calcareous soil)

IT Heavy **metals**
RL: BPR (Biological process); BSU (Biological study, unclassified); POL (Pollutant); REM (Removal or disposal); BIOL (Biological study); OCCU (Occurrence); PROC (Process)
(use of nitrilotriacetate and sulfur amendments in enhancement of **phytoextn.** of Zn, Cd, and Cu from calcareous soil)

IT 10544-50-0, Sulfur S8, biological studies 28528-44-1, Nitrilotriacetate
RL: BPR (Biological process); BSU (Biological study, unclassified); MOA (Modifier or additive use); BIOL (Biological study); PROC (Process); USES (Uses)
(use of nitrilotriacetate and sulfur amendments in enhancement of **phytoextn.** of Zn, Cd, and Cu from calcareous soil)

IT 7440-43-9, Cadmium, processes 7440-50-8, Copper, processes 7440-66-6, Zinc, processes
RL: BPR (Biological process); BSU (Biological study, unclassified); POL (Pollutant); REM (Removal or disposal); BIOL (Biological study); OCCU (Occurrence); PROC (Process)
(use of nitrilotriacetate and sulfur amendments in enhancement of **phytoextn.** of Zn, Cd, and Cu from calcareous soil)

REFERENCE COUNT: 40 THERE ARE 40 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 15 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2000:60601 HCAPLUS
DOCUMENT NUMBER: 132:224973
TITLE: **Phyto-mining** for **nickel**, thallium and gold
AUTHOR(S): Anderson, C. W. N.; Brooks, R. R.; Chiarucci, A.;

LaCoste, C. J.; Leblanc, M.; Robinson, B. H.; Simcock, R.; Stewart, R. B.
CORPORATE SOURCE: Institute of Natural Resources, Soil and Earth Sciences, Massey University, Palmerston North, N. Z.
SOURCE: Journal of Geochemical Exploration (1999), 67(1-3), 407-415
CODEN: JGCEAT; ISSN: 0375-6742
PUBLISHER: Elsevier Science B.V.
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 26 Jan 2000
AB The technique of phyto mining involves growing a crop of a metal-hyper-accumulating plant species, harvesting the biomass and burning it to produce a bio-ore. The first phyto mining expts. were carried out in California using the Ni-hyper accumulator Streptanthus polygaloides and it was found that a yield of 100 kg/ha of sulfur-free Ni could be produced. We have used the same technique to test the phyto mining potential of the Ni-hyper accumulators Alyssum bertolonii from Italy and Berkheya coddii from South Africa. The effect of different fertilizer treatments on growth of Alyssum bertolonii was established in situ in Tuscany and showed that the biomass of the plant could be increased by a factor of nearly 3 (4.5 t/ha to 12 t/ha) without significant loss of the Ni concentration (7600 mg/kg) in the plant. Analogous expts. have been carried out on Berkheya coddii where a biomass yield of over 20 t/ha can readily be achieved though the Ni concentration is not as high as in A. bertolonii. The total yield is, however, much greater. We have also been able to induce plants to hyper accumulate Au by adding ammonium thiocyanate to the substrate. Up to 57 mg/kg Au (dry mass) could be accumulated by Indian mustard (Brassica juncea). Usual hyper accumulation (>500 mg/kg dry mass) of Tl has been determined in Iberis intermedia and Biscutella laevigata (Brassicaceae) from southern France. The Iberis contained up to 0.4% Tl (4000 mg/kg) in the whole-plant dry matter and the Biscutella over 1.5%. This unusually high accumulation of Tl has significance for animal and human health, phyto remediation of contaminated soils, and phyto mining for Tl. Using Iberis, a net return of US 1200/ha (twice the return from a crop of wheat) would be possible with a biomass yield of 10 t/ha containing 0.08% Tl in dry matter. The break-even point (net yield of US 500/ha) would require 170 mg/kg (0.017%) Tl in dry matter. A model of a phyto mining operation and its economics is presented and its advantages and disadvantages discussed.
CC 53-2 (Mineralogical and Geological Chemistry)
ST **nickel** thallium gold ore prodn plants **phyto mining** model
IT **Alyssum** bertolonii
Berkheya coddii
Biscutella laevigata
Brassica juncea
Candytuft (Iberis intermedia)
Plant (Embryophyta)
Simulation and Modeling, physicochemical
Streptanthus polygaloides
(**phyto-mining** for **nickel**, thallium and gold by using plants)
IT Gold ores
Nickel ores
Thallium ores
RL: BPR (Biological process); BSU (Biological study, unclassified); BUU (Biological use, unclassified); BIOL (Biological study); PROC (Process); USES (Uses)

(**phyto-mining** for **nickel**, thallium and gold by using plants)
REFERENCE COUNT: 23 THERE ARE 23 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 16 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 2000:39318 HCAPLUS
DOCUMENT NUMBER: 132:82922
TITLE: Heavy **metal** accumulation in wild plants: implications for **phytoremediation**
AUTHOR(S): Porebska, G.; Ostrowska, A.
CORPORATE SOURCE: Institute of Environmental Protection, Warsaw, 00-548, Pol.
SOURCE: Polish Journal of Environmental Studies (1999), 8(6), 433-442
CODEN: PJESE2; ISSN: 1230-1485
PUBLISHER: HARD Publishing Co.
DOCUMENT TYPE: Journal
LANGUAGE: English
ED Entered STN: 18 Jan 2000
AB The issue of Zn, Cu, Pb, Cd, Ni, and Cr accumulation in wild-grown plants in the context of their possible use for treatment of sludge and waste substrates is discussed. Highest heavy metal content was noted in Lactuca serriola, Chenopodium album, Artemisia vulgaris, and Atriplex nitens. Assuming maximum crop production to be obtained from sludge and waste substrates at 2 kg dry wt/m2, it is clear that from 1 ha, several hundred grams of Pb and Cd and up to 2 kg of Cu and 20 kg of Zn may be removed.
CC 60-4 (Waste Treatment and Disposal)
Section cross-reference(s): 11, 19
ST wild plant heavy **metal** accumulation; waste solids contaminated soil **phytoremediation**; sludge heavy **metal** accumulation wild plant; landfill heavy **metal** accumulation wild plant
IT Soils
(contaminated, industrial sites; heavy **metal** accumulation by wild plants and implications for polluted site **phytoremediation**)
IT **Alyssum** murale
Artemisia vulgaris
Atriplex nitens
Chenopodium album
Clover (Trifolium repens)
Corn
Dicotyledon (Magnoliopsida)
Elytrigia repens
Lactuca serriola
Monocotyledon (Liliopsida)
Pennycress (Thlaspi caerulescens)
Soil pollution
Soil reclamation
Willow (Salix viminalis)
(heavy **metal** accumulation by wild plants and implications for polluted site **phytoremediation**)
IT Heavy **metals**
RL: BOC (Biological occurrence); BPR (Biological process); BSU (Biological study, unclassified); POL (Pollutant); REM (Removal or disposal); BIOL (Biological study); OCCU (Occurrence); PROC (Process)
(heavy **metal** accumulation by wild plants and implications for polluted site **phytoremediation**)
IT Solid wastes

(landfill; heavy **metal** accumulation by wild plants and implications for polluted site **phytoremediation**)
IT **Remediation**
(**phyto**-; heavy **metal** accumulation by wild plants and implications for polluted site **phytoremediation**)
IT Sludges
(**phytoremediation** treatment of; heavy **metal** accumulation by wild plants and implications for polluted site **phytoremediation**)
IT Barley
(straw and grain; heavy **metal** accumulation by wild plants and implications for polluted site **phytoremediation**)
IT Potato (Solanum tuberosum)
(tuber; heavy **metal** accumulation by wild plants and implications for polluted site **phytoremediation**)
IT Compost
(waste solids; heavy **metal** accumulation by wild plants and implications for polluted site **phytoremediation**)
IT Plant (Embryophyta)
(wild; heavy **metal** accumulation by wild plants and implications for polluted site **phytoremediation**)
IT 7439-92-1, Lead, processes **7440-02-0**, **Nickel**, processes 7440-43-9, Cadmium, processes 7440-47-3, Chromium, processes 7440-50-8, Copper, processes 7440-66-6, Zinc, processes
RL: BOC (Biological occurrence); BPR (Biological process); BSU (Biological study, unclassified); POL (Pollutant); REM (Removal or disposal); BIOL (Biological study); OCCU (Occurrence); PROC (Process)
(heavy **metal** accumulation by wild plants and implications for polluted site **phytoremediation**)
REFERENCE COUNT: 21 THERE ARE 21 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L28 ANSWER 17 OF 17 HCAPLUS COPYRIGHT 2005 ACS on STN
ACCESSION NUMBER: 1998:377774 HCAPLUS
DOCUMENT NUMBER: 129:148490
TITLE: Fertilization of hyperaccumulators to enhance their potential for **phytoremediation** and **phytomining**
AUTHOR(S): Bennett, F. A.; Tyler, E. K.; Brooks, R. R.; Gregg, P. E. H.; Stewart, R. B.
CORPORATE SOURCE: Department of Soil Science, Massey University, Palmerston North, N. Z.
SOURCE: Plants That Hyperaccumulate Heavy Metals (1998), 249-259. Editor(s): Brooks, Robert R. CAB International: Wallingford, UK.
CODEN: 66FLA6
DOCUMENT TYPE: Conference
LANGUAGE: English
ED Entered STN: 20 Jun 1998
AB N fertilization increased the biomass of 3 hyperaccumulating plant species studied, whereas there was no difference in biomass or metal uptake for varying P concns. at constant N levels. Alyssum bertolonii and Thlaspi caerulescens showed a slight reduction in concentration of Ni and Zn resp. when the
biomass increased. Alyssum and Streptanthus polygaloides were suitable for **phytomining**; the has phytoremedial potential as a hyperaccumulator of Ni.
CC 19-5 (Fertilizers, Soils, and Plant Nutrition)
Section cross-reference(s): 53
ST fertilizer hyperaccumulator **phytoremediation phytomining**

metal
IT Remediation
(bioremediation, **phytoremediation**; nitrogen and phosphorus fertilization effect on hyperaccumulators in relation to potential for)
IT Environmental pollution
(heavy **metal**; hyperaccumulators response to fertilization in relation to potential for **phytomining** and **phytoremediation**)
IT Trace **metals**
RL: BPR (Biological process); BSU (Biological study, unclassified); POL (Pollutant); PUR (Purification or recovery); REM (Removal or disposal); BIOL (Biological study); OCCU (Occurrence); PREP (Preparation); PROC (Process)
(heavy; hyperaccumulators response to fertilization in relation to potential for **phytomining** and **phytoremediation**)
IT **Alyssum** bertolonii
Pennycress (Thlaspi caerulescens)
Streptanthus polygaloides
(hyperaccumulators response to fertilization in relation to potential for **phytomining** and **phytoremediation**)
IT Fertilizer experiment
(nitrogen and phosphorus fertilization effect on hyperaccumulators in relation to potential for **phytoremediation** and **phytomining**)
IT Mining
(**phytomining**; nitrogen and phosphorus fertilization effect on hyperaccumulators in relation to potential for)
IT Heavy **metals**
RL: BPR (Biological process); BSU (Biological study, unclassified); POL (Pollutant); PUR (Purification or recovery); REM (Removal or disposal); BIOL (Biological study); OCCU (Occurrence); PREP (Preparation); PROC (Process)
(trace; hyperaccumulators response to fertilization in relation to potential for **phytomining** and **phytoremediation**)
IT 7727-37-9, Nitrogen, biological studies
RL: AGR (Agricultural use); BAC (Biological activity or effector, except adverse); BSU (Biological study, unclassified); BIOL (Biological study); USES (Uses)
(hyperaccumulators response to fertilization in relation to potential for **phytomining** and **phytoremediation**)
IT **7440-02-0P**, **Nickel**, biological studies 7440-66-6P, Zinc, biological studies
RL: BPR (Biological process); BSU (Biological study, unclassified); POL (Pollutant); PUR (Purification or recovery); REM (Removal or disposal); BIOL (Biological study); OCCU (Occurrence); PREP (Preparation); PROC (Process)
(hyperaccumulators response to fertilization in relation to potential for **phytomining** and **phytoremediation**)
REFERENCE COUNT: 11 THERE ARE 11 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

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=> fil biosis agricola
'AGRICOLA' IS NOT A VALID FILE NAME
ENTER A FILE NAME OR (IGNORE): end

=> fil biosis agricola
FILE 'BIOSIS' ENTERED AT 11:00:57 ON 22 AUG 2005

FILE 'AGRICOLA' ENTERED AT 11:00:57 ON 22 AUG 2005

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=> d que l38
L1             1 SEA FILE=REGISTRY ABB=ON  PLU=ON  COBALT/CN
L2             1 SEA FILE=REGISTRY ABB=ON  PLU=ON  NICKEL/CN
L29        27070 SEA L1 OR L2
L31       622763 SEA SOIL#
L32        62286 SEA L29 OR NI OR COBALT OR NICKEL
L34          441 SEA ALYSSUM
L35          125 SEA L32 AND L34
L37           76 SEA L35 AND L31
L38           10 SEA L37 AND PH

=> d que l39
L1             1 SEA FILE=REGISTRY ABB=ON  PLU=ON  COBALT/CN
L2             1 SEA FILE=REGISTRY ABB=ON  PLU=ON  NICKEL/CN
L29        27070 SEA L1 OR L2
L31       622763 SEA SOIL#
L32        62286 SEA L29 OR NI OR COBALT OR NICKEL
L34          441 SEA ALYSSUM
L35          125 SEA L32 AND L34
L37           76 SEA L35 AND L31
L38           10 SEA L37 AND PH
L39            8 DUP REM L38 (2 DUPLICATES REMOVED)

=> d ibib ab ct 1-8

L39  ANSWER 1 OF 8  BIOSIS  COPYRIGHT (c) 2005 The Thomson Corporation  on STN
ACCESSION NUMBER:   2005:121069  BIOSIS
DOCUMENT NUMBER:    PREV200500120257
TITLE:              Metal extraction by Alyssum serpyllifolium ssp.
                    lusitanicum on mine-spoil soils from Spain.
AUTHOR(S):          Kidd, P. S. [Reprint Author]; Monterroso, C.
CORPORATE SOURCE:   IIAG, CSIC, Campus Univ,Aptdo 122, Santiago De Compostela,
                    15780, Spain
                    edpetra@usc.es
SOURCE:             Science of the Total Environment, (January 5 2005) Vol.
                    336, No. 1-3, pp. 1-11. print.
                    ISSN: 0048-9697 (ISSN print).
DOCUMENT TYPE:      Article
LANGUAGE:           English
ENTRY DATE:         Entered STN: 23 Mar 2005
                    Last Updated on STN: 23 Mar 2005
AB   The efficiency of Alyssum serpyllifolium ssp. lusitanicum
     (Brassicaceae) for use in phytoextraction of polymetallic contaminated
     soils was evaluated.  A. serpyllifolium was grown on two
     mine-spoil soils (MS1 and MS2): MS1 is contaminated with Cr (283
     mg kg-1) and MS2 is moderately contaminated with Cr (263 mg kg-1), Cu (264
     mg kg-1), Pb (1433 mg kg-1) and Zn (377 mg kg-1).  Soils were
     limed to about pH 6.0 (MS1/Ca and MS2/Ca) or limed and amended
     with NPK fertilisers (MS1/NPK and MS2/NPK).  Biomass was reduced on MS2/Ca
     due to Cu phytotoxicity.  Fertilisation increased biomass by 10-fold on
     MS1/NPK, but root growth was reduced by 7-fold compared with MS1/Ca.
     Plants accumulated Mn, Ni and Zn in shoots, and both metal
     content and transportation were generally greater in MS2 than in MS1.
     Zinc bioaccumulation factors (BF, shoot(metal)/soil(metal))were
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significantly greater in MS2 than in MSL However, metal yields were greatest in plants grown on MS1/NPK. Concentrations of EDTA-, NH4Cl- and Mehlich 3 (M3)-extractable Mn and Zn were greater after plant growth. Concentrations of W-extractable Cr, **Ni**, Pb and Zn were increased at the rhizosphere. Sequential extractions showed changes in the metal distribution among different **soil** fractions after growth. This could reflect the buffering capacity of these **soils** or the plants' ability to mobilise metals from less plant-available **soil** pools. Results suggest that A. serpyllifolium could be suitable for phytoextraction uses in polymetallic-contaminated **soils**, provided Cu concentrations were not phytotoxic. However, further optimisation of growth and metal extraction are required.

IT Major Concepts
Methods and Techniques; Pollution Assessment Control and Management; **Soil** Science; Toxicology

IT Parts, Structures, & Systems of Organisms
root; shoot

IT Chemicals & Biochemicals
chromium: pollutant, **soil** pollutant; copper: phytotoxin, toxin; lead: pollutant, **soil** pollutant; manganese: pollutant, **soil** pollutant; **nickel**: pollutant, **soil** pollutant; nitrogen: agrichemical, fertilizer; phosphorus: agrichemical, fertilizer; potassium: agrichemical, fertilizer; zinc: bioaccumulation, pollutant, **soil** pollutant

L39 ANSWER 2 OF 8 BIOSIS COPYRIGHT (c) 2005 The Thomson Corporation on STN
DUPLICATE 1

ACCESSION NUMBER: 2005:89386 BIOSIS
DOCUMENT NUMBER: PREV200500086383
TITLE: The effect of **pH** on metal accumulation in two **Alyssum** species.
AUTHOR(S): Kukier, Urszula [Reprint Author]; Peters, Carinne A.; Chaney, Rufus L.; Angle, J. Scott; Roseberg, Richard J.
CORPORATE SOURCE: Anim Manure and Byprod LabBARCW, USDA ARS, Bldg 007, Beltsville, MD, 20705, USA
kukieru@ba.ars.usda.gov
SOURCE: Journal of Environmental Quality, (November 2004) Vol. 33, No. 6, pp. 2090-2102. print.
ISSN: 0047-2425 (ISSN print).
DOCUMENT TYPE: Article
LANGUAGE: English
ENTRY DATE: Entered STN: 2 Mar 2005
Last Updated on STN: 2 Mar 2005

AB **Nickel** phytoextraction using hyperaccumulator plants offers a potential for profit while decontaminating **soils.** Although **soil pH** is considered a key factor in metal uptake by crops, little is known about **soil pH** effects on metal uptake by hyperaccumulator plants. Two **Ni** and Co hyperaccumulators, **Alyssum** murale and A. corsicum, were grown in Quarry muck (Terric Haplohemist) and Welland (Typic Epiaquoll) **soils** contaminated by a **Ni** refinery in Port Colborne, Ontario, Canada, and in the serpentine Brockman **soil** (Typic Xerochrepts) from Oregon, USA. **Soils** were acidified and limed to cover **pH** from strongly acidic to mildly alkaline. **Alyssum** grown in both industrially contaminated **soils** exhibited increased **Ni** concentration in shoots as **soil pH** increased despite a decrease in water-soluble **soil Ni**, opposite to that seen with agricultural crop plants. A small decrease in **Alyssum** shoot **Ni** concentration as

soil pH increased was observed in the serpentine **soil.** The highest fraction of total **soil Ni** was phytoextracted from Quarry muck (6.3%), followed by Welland (4.7%), and Brockman (0.84%). Maximum **Ni** phytoextraction was achieved at **pH** 7.3, 7.7, and 6.4 in the Quarry, Welland, and Brockman **soils**, respectively. **Cobalt** concentrations in shoots increased with **soil pH** increase in the Quarry muck, but decreased in the Welland **soil.** Plants extracted 1.71, 0.83, and 0.05% of the total **soil** Co from Welland, Quarry, and Brockman, respectively. The differences in uptake pattern of **Ni** and Co by **Alyssum** from different **soils** and **pH** were probably related to the differences in organic matter and iron contents of the **soils.**

IT Major Concepts
Conservation; Pollution Assessment Control and Management; **Soil** Science; Terrestrial Ecology (Ecology, Environmental Sciences)

IT Parts, Structures, & Systems of Organisms
shoot

IT Chemicals & Biochemicals
cobalt: pollutant, **soil** pollutant; **nickel** : pollutant, **soil** pollutant

L39 ANSWER 3 OF 8 BIOSIS COPYRIGHT (c) 2005 The Thomson Corporation on STN

ACCESSION NUMBER: 2003:198099 BIOSIS
DOCUMENT NUMBER: PREV200300198099
TITLE: Phytoextraction of **nickel** and **cobalt** by hyperaccumulator **Alyssum** species grown on **nickel**-contaminated **soils.**
AUTHOR(S): Li, Yin-M. [Reprint Author]; Chaney, Rufus L.; Brewer, Eric P.; Angle, J. Scott; Nelkin, Jay
CORPORATE SOURCE: Viridian Environmental L.L.C., 5417 Chaucer, P.O. Box 25303, Houston, TX, 77265, USA yli@viridianllc.com
SOURCE: Environmental Science & Technology, (April 1 2003) Vol. 37, No. 7, pp. 1463-1468. print. ISSN: 0013-936X (ISSN print).
DOCUMENT TYPE: Article
LANGUAGE: English
ENTRY DATE: Entered STN: 23 Apr 2003 Last Updated on STN: 23 Apr 2003

AB Several **Alyssum** species native to Mediterranean serpentine **soils** hyperaccumulate **nickel.** These species can potentially be used to remediate **Ni**-contaminated **soils** . However, the ability of these species to phytoextract **Ni** from nonserpentine **Ni**-contaminated **soils** is unknown. Two **Ni** hyperaccumulator species, **Alyssum** murale and **Alyssum** corsicum, were grown for 120 days on two nonserpentine **Ni**-contaminated **soils** in a greenhouse experiment. **Soils** were amended to provide a range of values for three **soil** factors: **soil pH**, available phosphorus, and exchangeable Ca/Mg ratio. Both species hyperaccumulated **Ni**, but not Co, from both **soils.** **Ni** uptake was reduced at lower **soil pH** and increased at higher **soil pH.** Neither P fertilization nor adjustment of the exchangeable Ca/Mg ratio significantly affected phytoextraction of **Ni** or Co. There was no difference between the two species in the amount of **Ni** phytoextracted, but A. corsicum phytoextracted more Co than A. murale. Higher amounts of both metals were phytoextracted from the loam than from the organic **soil.** Further research is needed to better understand the unusual effect of **soil pH**

adjustment on **Ni** uptake by these hyperaccumulator species.
IT Major Concepts
Pollution Assessment Control and Management; **Soil** Science
IT Chemicals & Biochemicals
cobalt: bioaccumulation, phytoextraction, **soil** pollutant, toxin; **nickel**: bioaccumulation, phytoextraction, **soil** pollutant, toxin

L39 ANSWER 4 OF 8 BIOSIS COPYRIGHT (c) 2005 The Thomson Corporation on STN
ACCESSION NUMBER: 2004:125776 BIOSIS
DOCUMENT NUMBER: PREV200400127946
TITLE: Phenotypic characterization of microbes in the rhizosphere of **Alyssum** murale.
AUTHOR(S): Abou-Shanab, R. I.; Delorme, T. A.; Angle, J. S. [Reprint Author]; Chaney, R. L.; Ghanem, K.; Moawad, H.; Ghozlan, H. A.
CORPORATE SOURCE: Department of Natural Resource Sciences, University of Maryland, College Park, 20742, USA
ja35@umail.umd.edu
SOURCE: International Journal of Phytoremediation, (2003) Vol. 5, No. 4, pp. 367-379. print.
ISSN: 1522-6514 (ISSN print).
DOCUMENT TYPE: Article
LANGUAGE: English
ENTRY DATE: Entered STN: 3 Mar 2004
Last Updated on STN: 3 Mar 2004
AB Metal hyperaccumulator plants like **Alyssum** murale are used for phytoremediation of **Ni** contaminated **soils.** **Soil** microorganisms are known to play an important role in nutrient acquisition for plants, however, little is known about the rhizosphere microorganisms of hyperaccumulators. Fresh and dry weight, and **Ni** and Fe concentrations in plant shoots were higher when A. murale was grown in non-sterilized compared to sterilized **soils.** The analysis of microbial populations in the rhizosphere of A. murale and in bulk **soils** demonstrated that microbial numbers were affected by the presence of the plant. Significantly higher numbers of culturable actinomycetes, bacteria and fungi were found in the rhizosphere compared to bulk **soil.** A higher percent of **Ni**-resistant bacteria were also found in the rhizosphere compared to bulk **soil** . Percentage of acid producing bacteria was higher among the rhizosphere isolates compared to isolates from bulk **soil.** However, proportions of siderophore producing and phosphate solubilizing bacteria were not affected by the presence of the plant. We hypothesize that microbes in the rhizosphere of A. murale were capable of reducing **soil pH** leading to an increase in metal uptake by this hyperaccumulator.
IT Major Concepts
Bioprocess Engineering; Pollution Assessment Control and Management; **Soil** Science
IT Parts, Structures, & Systems of Organisms
shoot, dry weight, fresh weight, iron concentration, **nickel** concentration

L39 ANSWER 5 OF 8 BIOSIS COPYRIGHT (c) 2005 The Thomson Corporation on STN
DUPLICATE 2
ACCESSION NUMBER: 2003:216385 BIOSIS
DOCUMENT NUMBER: PREV200300216385
TITLE: Development of a technology for commercial phytoextraction of **nickel**: Economic and technical considerations.
AUTHOR(S): Li, Yin-M. [Reprint Author]; Chaney, Rufus; Brewer, Eric;

Roseberg, Richard; Angle, J. Scott; Baker, Alan; Reeves, Roger; Nelkin, Jay
CORPORATE SOURCE: Viridian Environ. L.L.C., Houston, TX, USA
yli@viridianllc.com
SOURCE: Plant and Soil, (February 2003) Vol. 249, No. 1, pp. 107-115. print.
ISSN: 0032-079X (ISSN print).
DOCUMENT TYPE: Article
LANGUAGE: English
ENTRY DATE: Entered STN: 30 Apr 2003
Last Updated on STN: 30 Apr 2003

AB In recent R & D work, we have made progress in developing a commercial technology using hyperaccumulator plant species to phytoextract **nickel** (**Ni**) from contaminated and/or **Ni**-rich **soils.** An on-going program is being carried out to develop a genetically improved phytoextraction plant that combines favorable agronomic and **Ni** accumulation characteristics. Genetically diverse **Ni** hyperaccumulator species and ecotypes of **Alyssum** were collected and then evaluated in both greenhouse and field using serpentine and **Ni**-refinery contaminated **soils.** Large genetic variation was found in those studies. Mean shoot **Ni** concentrations in field-grown plants ranged from 4200 to 20 400 mg kg-1. We have been studying several **soil** management practices that may affect the efficiency of **Ni** phytoextraction. **Soil pH** is an important factor affecting absorption of metals by plants. An unexpected result of both greenhouse and field experiments was that **Ni** uptake by two **Alyssum** species was reduced at lower **soil pH** and increased at higher **soil pH.** At higher **pH** , plant yield was improved also. In **soil** fertility management studies, we found that N application significantly increased plant biomass, but did not affect plant shoot **Ni** concentration. These findings indicate that **soil** management will be important for commercial phytoextraction. A number of field trials have been carried out to study planting methods, population density, weed control practices, harvest schedule and methods, pollination control, and seed processing. Such crop management studies have improved phytoextraction efficiency and provide a tool for farmers to conduct commercial production. We have done some work to develop efficient and cost-effective methods of **Ni** recovery. Recovery of energy by biomass burning or pyrolysis could help make phytoextraction more cost-effective. The progress made in our recent studies will enable us to apply this technology commercially in the near future.

IT Major Concepts
Methods and Techniques; Pollution Assessment Control and Management; **Soil** Science
IT Chemicals & Biochemicals
nickel: accumulation, toxic heavy metal, uptake, pollutant, **soil** pollutant

L39 ANSWER 6 OF 8 BIOSIS COPYRIGHT (c) 2005 The Thomson Corporation on STN
ACCESSION NUMBER: 1995:69075 BIOSIS
DOCUMENT NUMBER: PREV199598083375
TITLE: Comparison of the chemical changes in the rhizosphere of the **nickel** hyperaccumulator **Alyssum** murale with the non-accumulator Raphanus sativus.
AUTHOR(S): Bernal, M. P. [Reprint author]; McGrath, S. P.; Miller, A. J.; Baker, A. J. M.
CORPORATE SOURCE: Dep. Organic Resour., Cent. Edafol. Biol. Aplicada Segura, CSIC, Apartado 4195, 30080 Murcia, Spain

SOURCE: Plant and Soil, (1994) Vol. 164, No. 2, pp. 251-259.
CODEN: PLSOA2. ISSN: 0032-079X.
DOCUMENT TYPE: Article
LANGUAGE: English
ENTRY DATE: Entered STN: 8 Feb 1995
Last Updated on STN: 9 Feb 1995

AB Changes in **pH** and redox potential were studied in the rhizosphere **soil** of a **nickel** hyperaccumulator plant (**Alyssum** murale) and of a crop plant, radish (Raphanus sativus). Differences in rhizosphere **pH** and reducing activity were found between the lateral and the main roots of both species, but the **pH** changes in the rhizosphere were similar in both species. Changes in **pH** were associated with the relative uptakes of cations and anions; whether the concentrations of heavy metals in the growth medium did not have any effect on the rhizosphere **pH.** The source of nitrogen (ammonium or nitrate) was the major factor determining the **pH** of the rhizosphere of both species. The redox potential of the rhizosphere was influenced by both the N-source and the concentrations of heavy metals. When heavy metals were not present in the growth medium, and nitrate was the N-source, the reducing capacity of A. murale roots was enhanced. However, the reducing activity of A. murale was always smaller than that of radish. Therefore, the mechanism of metal solubilization by the hyperaccumulator plant does not involve either the reduction of **pH** in the rhizosphere or the release of reductants from roots. The acidification and reducing activity of the roots of A. murale was always smaller than that of R. sativus.

IT Major Concepts
Nutrition; Pathology; Physiology; **Soil** Science

IT Chemicals & Biochemicals
NICKEL; NITROGEN

L39 ANSWER 7 OF 8 BIOSIS COPYRIGHT (c) 2005 The Thomson Corporation on STN
ACCESSION NUMBER: 1995:162408 BIOSIS
DOCUMENT NUMBER: PREV199598176708
TITLE: Effects of **pH** and heavy metal concentrations in solution culture on the proton release, growth and elemental composition of **Alyssum** murale and Raphanus sativus L.
AUTHOR(S): Bernal, M. P. [Reprint author]; McGrath, S. P.
CORPORATE SOURCE: Dep. Org. Resources, Cent. Edafol. Biol. Aplicada Segura, CSIC, PO Box 4195, 30080 Murcia, Spain
SOURCE: Plant and Soil, (1994) Vol. 166, No. 1, pp. 83-92.
CODEN: PLSOA2. ISSN: 0032-079X.
DOCUMENT TYPE: Article
LANGUAGE: English
ENTRY DATE: Entered STN: 11 Apr 1995
Last Updated on STN: 12 Apr 1995

AB The proton release by a species that can hyperaccumulate **nickel** (**Alyssum** murale) and by a non-accumulator (Raphanus sativus L.) was studied at different **pH** and heavy metal concentrations in solution culture. Both factors influenced the growth and composition of the plants. A. murale was more sensitive than radish to a decrease of **pH** from 7.0 to 6.0 in the growth medium; plant yield and proton production diminished with decreasing **pH.** However, yields and proton production of radish only decreased at **pH** 5.5. The differences in the amounts of protons produced between the hyperaccumulator species and radish were not large enough to conclude that decreasing **pH** in the rhizosphere of A. murale is a mechanism for heavy metal solubilization. **Nickel** concentrations in A. murale followed the typical pattern of an accumulator plant - more **Ni**

was accumulated in the shoots than in the roots. Lower concentrations of Zn and Cd occurred in the shoots than in roots of A. murale, and also of **Ni** in radish. The concentrations of Co in A. murale shoots were increased when Zn, **Ni** and Cd were absent from the nutrient solution. However, Co concentrations in radish shoots were independent of the concentrations of other heavy metals in the growth medium.

IT Major Concepts
Biochemistry and Molecular Biophysics; Development; Horticulture (Agriculture); Pathology; Physiology; **Soil** Science; Toxicology

IT Chemicals & Biochemicals
NICKEL; CADMIUM; ZINC; **COBALT**

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AB The most representative vegetation of this submountain area is the deciduous forest of Quercion frainetto-All., under normal conditions. But the human factor on the one hand and the serpentine **soil** on the other hand have substituted forest vegetation to a large extent for dry steppic grasses among which **Alyssum** murale plays the most important role. Thus apart from the Quercus forest growing on a part of the area there are the Psilurus incurvus-Aegylops neglecta and the Onosma heterophylla-Silene fabarioides communities. Edaphic profiles and analyses of **soil** samples for **pH**, calcium carbonic, organic C, P, N and the alternative Ca, Mg, K, Na, **Ni** cations produced differences between the localities where these communities are present.

IT Major Concepts
Biogeography (Population Studies); Ecology (Environmental Sciences); Forestry; **Soil** Science

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